APPENDIX J7
Preliminary Water Quality Management Plan

PRELIMINARY WATER QUALITY MANAGEMENT PLAN (PWQMP)

Even though the current template is dated May 1, 2012, it is basically the same template from expired Santa Ana Regional Water Quality Control Board (SARWQCB), Order No. R8-2002-0012 (NPDES Permit No. CAS618036); this document has been modified to comply with current Order No. R8-2010-0036

for

Redlands Passenger Rail Project, Phase I (Preliminary Engineering)

Project No. _____

Location

BNSF Railroad Corridor, from E Street, City of San Bernardino to Cook Street, City of Redlands
REDLANDS SUBDIVISION – MP 1.0 to 10.0

Prepared for/Owned by:

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Date: December 17, 2012

PWQMP Disclaimer

This Preliminary Water Quality Management Plan (PWQMP) is only for purposes of obtaining approval of a 401 Water Quality Certification from the Santa Ana Regional Water Quality Control Board to satisfy requirements of the Environmental Document. SANBAG is not a co-permittee to the current San Bernardino County Municipal Separate Storm Sewer System (MS4) permit and is not required to submit the PWQMP to an agency for approval. However, the PWQMP will be submitted to the City of San Bernardino, City of Redlands and other stakeholders for courtesy review and comment.

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List of Acronyms and Abbreviations

BAT	Best Available Technology Economically Achievable
BCT	Best Conventional Pollution Control Technology
BMP	Best Management Practice
BNSF	Burlington Northern Santa Fe
Caltrans	California Department of Transportation
CASQA	California Stormwater Quality Association
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CGP	Construction General Permit
CTC	California Transportation Commission
CWA	Clean Water Act
DAMP	Drainage Area Management Plan
DTSC	Department of Toxic Substances Control
EA	Environmental Assessment
EHM	Engineered, Hardened, and Maintained
EIR	Environmental Impact Report
ESRI	Environmental Systems Research Institute, Inc.
GIS	Geographic Information System
HCOC	Hydrologic Conditions of Concern
I-10	Interstate 10
IGP	Industrial General Permit
IVDA	Inland Valley Development Agency
LID	Low Impact Development
LRP	Legally Responsible Person
MEP	Maximum Extent Practicable
MP	Mile Post
MPO	Metropolitan Planning Organization
MS4	Municipal Separate Storm Sewer System
MSWMP	Municipal Storm Water Management Program
NEPA	National Environmental Policy Act
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
POC	Pollutants of Concern
PS&E	Plans, Specifications, and Estimate
PWQMP	Preliminary Water Quality Management Plan
RMC	Redlands Municipal Code
ROW	Right-of-Way
RPRP	Redlands Passenger Rail Project
RTP	Regional Transportation Plan
RTPA	Regional Transportation Planning Agency

RUSLE	Revised Universal Soil Loss Equation
RWQCB	Regional Water Quality Control Board
SANBAG	San Bernardino Associated Governments
SAR	Santa Ana River
SBCFCD	San Bernardino County Flood District
SBVMWD	San Bernardino Valley Municipal Water District
SCAG	Southern California Association of Governments
SCS	Sustainable Communities Strategy
SIC	Standard Industrial Code
SUSMP	Standard Urban Storm Water Mitigation Plan
SWDR	Storm Water Data Report
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
WAP	Watershed Action Plan
WDID	Waste Discharge Identification
WQMP	Water Quality Management Plan
WQO	Water Quality Objectives
WRWQTR	Water Resources and Water Quality Technical Report
Z2DA	Zone 2 Drainage Area
Z3DA	Zone 3 Drainage Area

Executive Summary

The purpose of Preliminary Water Quality Control Board (PWQMP) is to obtain approval of a 401 Water Quality Certification from the Santa Ana Regional Water Quality Control Board (RWQCB) to satisfy the requirements of the Environmental Document. The PWQMP will provide a preliminary overview and analysis of stormwater quality impacts resulting from the Project (Redlands Passenger Rail Project (RPRP)).

The Project is located within the eastern portion of the San Bernardino Valley, within the southwestern corner of the County of San Bernardino, California. The Study Area for the Project follows an approximate nine-mile railroad Right-of-Way (ROW) owned by the San Bernardino Associated Governments (SANBAG) extending from the City of San Bernardino on the west to the City of Redlands on the east. The Project would consist of the construction of transit infrastructure and operation of passenger rail service between E Street in the City of San Bernardino and the University of Redlands in the City of Redlands. Passenger rail service would be facilitated via five station stops. SANBAG proposes the replacement of the existing rail line, reconstruction of existing bridge structures, construction of new station platforms and a train layover facility, and auxiliary improvements such as parking, drainage infrastructure, grade crossings, and pedestrian access as part of the Project.

The project is included in the Santa Ana River (SAR) Watershed and is divided by the SAR into the north/west segment and the south/east segment, with each side draining tributary onsite and offsite areas into the SAR either by surface flow, local drainage facilities, or major stormwater conveyance systems. The project is tributary to Reach 4 (downstream - minority) and Reach 5 (upstream - majority) of the SAR. San Bernardino County Flood Control District (SBCFCD) manages the major stormwater conveyance systems within San Bernardino County. Consequently, the project is located in Flood Control Zone 2 and 3 with the boundary between these zones lying along the SAR. Zone 2 and 3 lies west and east of the SAR and correspond to the north/west (Zone 2 Drainage Area (Z2DA)) and south/east (Zone 3 Drainage Area (Z3DA)) segment of the project, respectively.

The major stormwater conveyance systems that cross or are adjacent to the project are Warm Creek (Historic), Twin Creek, SAR, Mission Zanja Creek, and Mill Creek Zanja. The Z2DA and the Z3DA are part of the Warm Creek/Twin Creek and Zanja basins, respectively. Portions of City of San Bernardino and City of Redlands are located in both Zones. Beside SBCFCD, related drainage infrastructure tributary to the project is also under the jurisdiction of City of San Bernardino, City of Redlands, Caltrans and U.S. Army Corps of Engineers (USACE).

Similarly, the drainage from the Z3DA is part of the Mission Zanja drainage basin. The mainstem of the Mission Zanja drainage basin is the Zanja Creek which is the principal flood control facility for the City of Redlands. The Zanja Creek crosses the County of San Bernardino, City of Redlands, and City of San Bernardino. It consists of three segments. The Creek is a partially improved open channel from the SAR to 1st Street (City of Redlands) and is referred to as the

"Mission Zanja Channel." The Creek continues upstream under downtown Redlands from 1st Street to 9th Street (City of Redlands) as the "Mission Storm Drain." Finally, the "Mill Creek Zanja" is the upstream segment of the Creek system and extends from 9th Street to the Mill Creek confluence at the upstream (east) end (San Bernardino County).

The project is under the jurisdiction of the Santa Ana Regional Water Quality Control Board (RWQCB), Region 8. The SAR watershed is divided into Hydrologic Areas (HA) that are subdivided into Hydrologic Sub Areas (HSA). According to the Basin Plan of the Santa Ana RWQCB, the project is located within the Upper SAR HA 801.50; specifically HSA 801.52 (Bunker Hill) and 801.53 (Redlands) on the west and east end of the project, respectively, with the HSA boundary at approximately New York Street in the City of Redlands. However, the northern/western end of the project (from Mill Street north – City of San Bernardino) drains to Colton HSA 801.44 (part of Colton-Rialto HA 801.40) by way of the Warm Creek Bypass and Lytle Creek Channels which confluences with the SAR in Reach 4. The SAR transitions from Reach 5 to Reach 4 at the San Jacinto Fault, just southwest of the project area, which is the boundary between Bunker Hill HSA and Colton HSA. (Reach 4 is defined as the portion of the SAR from Mission Boulevard in City of Riverside to the San Jacinto Fault in City of San Bernardino).

The existing rail corridor consists of railroad tracks with side ditches surrounded by various land uses including residential, commercial, industrial and open spaces. The ditches convey storm runoff and the underlying soil provides some level of treatment to applicable pollutants mobilized by storms via infiltration. Expected pollutants of concern associated with rail projects include metals, organic compounds, sediments, trash and debris, and oil and grease. The proposed design within the rail right-of-way (ROW) and corridor will perpetuate existing drainage patterns and flows consistent with California Drainage Law. Also, since land use is not changing in the corridor, the proposed conditions would have the same expected pollutants of concern. These pollutants would be treated by the earthen ditches as well as perforated underdrain systems which are incorporated into the track ballast section.However, proposed improvements in the stations/platforms and parking lots will consider implementation of feasible Best Management Practices (BMPs) such as, but not limited to, vegetated swales, infiltration basins, rain gardens and permeable pavements during the final design phase. Emphasis will be focused on Low Impact Development (LID) techniques during BMP design. The proposed layover facility will also consider BMPs to mitigate any increase in runoff flow and volumes and will be coordinated with those required of the applicable industrial Storm Water Pollution Prevention Plan (SWPPP). The Project proposed to increase impervious area by 21 acres, and required water quality flow and volume is 6 cfs and 2.1 acres-feet, respectively. The soil disturbance area ranges from 129 to 144 acres.

Maintenance of required BMPs will be the responsibility of SANBAG for the rail ROW includeing the layover facility, and the local stakeholders, as agreed to with SANBAG, for the proposed stations and parking lots. Maintenance of post-construction BMPs in the layover facility will be coordinated with the industrial SWPPP.

Based on preliminary Project design and research of stormwater quality requirements, it was concluded that the Project does not significantly impact the area from a water quality perspective. During final design, the project will mitigate any increase in runoff and volume due to addition of impervious areas for flood control (less frequent storm events) and water quality (more frequent storm events) to not cause a Hydrologic Condition of Concern (HCOC). This will require coordination with the drainage improvement design. Also the project will mitigate water quality impacts by incorporating feasible and appropriate BMPs.

Project Site Information

Name of Project: Redlands Passenger Rail Project (Preliminary Engineering Phase)

Project Location: Along SANBAG railroad corridor, Redlands Subdivision (Mile Post (MP) 1.0/10.0), From E Street, City of San Bernardino to Cook Street, City of Redlands

Size of Significant Re-Development on an Already Developed Site (in acres): 129-144

Size of New Development (in feet^2): Not Applicable

Number of Home Subdivisions: Not Applicable

SIC Codes: 4011, 4013

Erosive Site Conditions? : Yes

Natural Slope More Than 25%? : No

PROJECT CATEGORY SELECTION

Check the appropriate project category below:

Project Categories

X	1. All significant re-development projects. Significant re-development is defined as the addition or creation of 5,000 or more square feet of impervious surface on an already developed site. This includes, but is not limited to, additional buildings and/or structures, extension of existing footprint of a building, construction of parking lots, etc. Where redevelopment results in an increase of less than fifty percent of the impervious surfaces of a previously existing development, and the existing development was not subject to Standard Urban Stormwater Management Plans (SUSMPs), the design standards apply only to the addition, and not the entire development. When the redevelopment results in an increase of more than fifty percent of the impervious surfaces, then a Water Quality Management Plan (WQMP) is required for the entire development (new and existing).
	2. Home subdivisions of 10 units or more. This includes single family residences, multi-family residence, condominiums, apartments, etc.
	3. Industrial/commercial developments of 100,000 square feet or more. Commercial developments include non-residential developments such as hospitals, educational institutions, recreational facilities, mini-malls, hotels, office buildings, warehouses, and light industrial facilities.
	4. Automotive repair shops with Standard Industrial Codes (SIC) codes 5013, 5014, 5541, 7532- 7534, 7536-7539).
	5. Restaurants where the land area of development is 5,000 square feet or more.
	6. Hillside developments of 10,000 square feet or more which are located on areas with known erosive soil conditions or where the natural slope is twenty-five percent or more.
	7. Developments of 2,500 square feet of impervious surface or more adjacent to (within 200 feet) or discharging directly into environmentally sensitive areas such as areas designated in the Ocean Plan as areas of special biological significance or water bodies listed on the Clean Water Act (CWA) Section 303(d) list of impaired waters.
	8. Parking lots of 5,000 square feet or more exposed to storm water. Parking lot is defined as land area or facility for the temporary storage of motor vehicles.
	The project does not fall into any of the categories described above. (If the project requires a precise plan of development [e.g. all commercial or industrial projects, residential projects of less than 10 dwelling units, and all other land development projects with potential for significant adverse water quality impacts] or subdivision of land, it is defined as a Non-Category Project.)

1. Introduction and Project Description

This section provides the reason for preparing this document including identification of water quality components that could result in impacts to the environment. This section identifies project objectives, the regional and project area location, existing setting, surrounding land uses, and characteristics of the proposed project.

1.1. Objective and Purpose

The Santa Ana Regional Water Quality Control Board (RWQCB) has adopted an area-wide Municipal Separate Storm Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for San Bernardino County (Order No R8-2010-0036, CAS618036) (Permit). City of San Bernardino and City of Redlands are co-permittees of the Permit. The Permit requires post-construction Best Management Practices (BMPs) to be implemented for new development and significant redevelopment, for both private and public agency projects. Each permittee, which includes local cities and the County, requires a project-specific Water Quality Management Plan (WQMP) to address the detrimental effects of urbanization on the beneficial uses of receiving waters, including effects caused by increased pollutant loads and changes in hydrology. Consequently, SANBAG is not a permittee to this Permit (nor are they included in Attachment 3 of the MS4 Permit "List of Other Entities with the Potential to Discharge Pollutants to the San Bernardino County Storm Water Conveyance System") and is not required to submit the Preliminary WQMP (PWQMP) to a local agency for approval. However, the PWQMP will be submitted to the City of San Bernardino, City of Redlands and other stakeholders for courtesy review and comment.

The purpose of the PWQMP is to obtain approval of a 401 Water Quality Certification from the Santa Ana RWQCB to satisfy the requirements of the Environmental Document. The PWQMP will provide a comprehensive overview and analysis of stormwater quality impacts resulting from the project, considering tributary onsite and offsite drainage from surface and subsurface sources.

1.2. Authorization and Focus

The scope of services for the PWQMP task as authorized by SANBAG is to prepare a PWQMP and associated analysis to identify potential impacts or changes to water quality within the corridor and as a result of the project. Depending on the results of the analysis, permanent BMPs may be proposed as mitigation measures to meet water quality goals for post construction.

The PWQMP and associated BMPs will be developed to meet the requirements of the co-permittees along the Redlands Corridor and as a part of the Regional Water

Quality Control Board's implementation Order No. R8-2010-0036 (NPDES No. CAS 618036) Area-wide Urban Storm Water Runoff Management Program, San Bernardino County MS4 Permit. This includes the evaluation of Low Impact Development (LID) techniques to be incorporated into the project where feasible.

The primary goal of LID is to preserve the project's footprint predevelopment hydrology. The effect of changes to runoff patterns caused by land use modifications, or hydromodification, may be reduced by recommending the use of structural and non-structural techniques that store, infiltrate, evaporate, and/or detain storm related runoff.

This report has been prepared in accordance with the Model Water Quality Management Plan Guidance and the WQMP template from the San Bernardino County Stormwater Program, dated February 14, 2012 (based on Order no. R8-2002-012), but modified to comply with the latest permit, Order No. R8-2010-0036. In spite of the date, the Guidance and template substantially reflect the same information from the previous documents consistent with expired permit (Order No. R8-2002-0012). Update of the PWQMP to be in compliance with the forthcoming regular or roadway WQMP templates (consistent with Order No. 2010-0036) is not part of this scope. These templates were scheduled for public release on July 29, 2011, and January 29, 2012, respectively, and are still forthcoming as of the date of this report.

The hydromodification map of the Hydromodification Assessment Technical Memorandum for San Bernardino County Flood Control District (SBCFCD), January 2011 (Draft Phase 1 Watershed Action Plan), identifies Mission Zanja Channel as having a high hydromodification classification from approximately the Gage Canal to Santa Ana River (SAR). The remaining segments near the projects are identified as an Engineered, Hardened, and Maintained (EHM) facility. Since the mandated Hydromodification Management Plan, as part of the Watershed Action Plan, has not been prepared or approved by the County, this scope does not include analysis and evaluation of hydromodification impacts along the Mission Zanja Channel from tributary drainages outside of project limits. It is not expected that the project will have unmitigated Hydrologic Conditions of Concern (HCOC).

Once completed, a draft and final PWQMP will be prepared and submitted to SANBAG for concurrence before it is submitted to the City of San Bernardino and City of Redlands for review in accordance with the project schedule. A meeting is proposed with both Cities before submittal of the PWQMP to SANBAG to receive feedback on the approach.

1.3. Project Staff

The following individuals from HDR Engineering were involved in preparation of this report:

- Bill Flores, Task Manager
- Steve Mano, Reviewer

1.4. Project Information

- Name of project owner: San Bernardino Associated Governments (SANBAG)
- Address of project owner: 1170 West 3rd Street, 2nd Floor, San Bernardino, CA 92410-1715
- Telephone for project owner: (909) 884-8276
- Project site address: BNSF Railroad Corridor, from E Street, City of San Bernardino to Cook Street, City of Redlands, Redlands Subdivision (MP 1.0 to 10.0).

1.5. Permits

It is anticipated that the following permits that impact water quality will be required for the project:

1. NPDES General Permit for Storm Water Discharges Associated with Construction Activity (Construction General Permit - CGP), Order No. 2009-0009-DWQ and (NPDES No. CAS000002) and amendments. Associated Waste Discharge Identification (WDID) number will be processed during the Plans, Specifications and Estimate (PS&E) phase;
2. State Water Resources Control Board Water Quality Order No. 97-03-DWQ NPDES General Permit No. CAS000001 (Industrial General Permit - IGP) Waste Discharge Requirements for Discharges of Storm Water Associated with Industrial Activities Excluding Construction Activities. If this project includes a layover facility, or maintenance yard, then compliance with this Order would be necessary;
3. General Waste Discharge Requirements for Discharges to Surface Waters that Pose an Insignificant (De Minimus) Threat to Water Quality (Order No. R8-2009-0003, NPDES No. CAG998001), Santa Ana RWQCB. If this project requires dewatering, then compliance with this Order would be necessary;

4. California Department of Transportation (Caltrans) Encroachment Permit;
5. SBCFCD Encroachment Permit;
6. U.S. Army Corps of Engineers (USACE) Section 404 Nationwide Permit;
7. USACE Section 408 Permit;
8. California Department of Fish and Game Section 1602 Streambed Alteration Agreement; and
9. RWQCB Section 401 Water Quality Certification.

It is anticipated that the following discretionary permits will not be required from local agencies for the Project: grading permits, building permits, etc. These permits would normally trigger a formal submittal of the project PWQMP to the local agencies for approval. However this is not the case; see Section 1.1.

Encroachment permits will be required from City of San Bernardino and City of Redlands for the Grade Crossing Improvements and Caltrans for the two Interstate 10 (I-10) Overpass crossings. As a ministerial permit, the encroachment permit is not expected to trigger a formal requirement to submit the PWQMP.

The Interstate 10 (I-10) passes over the Project at two locations along the corridor (MP 5.65 and MP 9.48). It is understood that SANBAG has senior rights over Caltrans with regard to the freeway. However, an encroachment permit may still be required to modify or otherwise construct railroad facilities around Caltrans facilities. It is assumed a cooperative agreement will be required between SANBAG and Caltrans and that this agreement will stipulate the type of permit to be issued. It is assumed a Caltrans Storm Water Data Report will not required.

1.6. Project Description

The project proposes to re-introduce passenger rail service along the existing railroad right-of-way (ROW) owned by SANBAG from the City of San Bernardino on the west to the City of Redlands on the east, in southwestern San Bernardino County, California (see Figure 1, Regional Location and Project Area Map). This ROW is commonly referred to as the "Redlands Branch Line" and the "Redlands Subdivision, Redlands Spur, or Redlands Corridor." The entire Redlands Corridor is an approximately 10-mile rail segment that extends from the Santa Fe Depot in the City of San Bernardino to the University of Redlands in the City of Redlands. As a part of this project, most of the existing railroad infrastructure would be reconstructed as described in more detail below. The Project Study Area for the Redlands Passenger Rail Project (RPRP) extends from E Street in the City of San Bernardino to Cook Street in the City of Redlands. This linear corridor area will be evaluated in the Environmental Impact Report/Environmental Assessment (EIR/EA) and is generally limited to the existing railroad ROW and, in limited instances, areas immediately adjacent (e.g., generally less than 200 feet from the rail ROW).

The Project would include the development of new railroad infrastructure along an approximate nine-mile section of rail corridor owned by SANBAG and part of the former Atchison, Topeka and Santa Fe (now the Burlington Northern Santa Fe Railway (BNSF)) Railroad's Redlands Subdivision. SANBAG purchased this piece of the railroad along with others in the County from the BNSF in 1993 along with other agencies in Southern California and as a part of the divestiture of the physical assets of the BNSF. The Project would include the development of five new stations consisting of boarding platforms with supporting amenities, parking, and pedestrian access improvements. The Project would include a new train layover/storage facility with storage tracks, a vehicle wash, a 10,000-square-foot building, and ancillary facilities. Track upgrades would include signal improvements, replacement or retrofit of four existing bridge structures, and approximately 28 at-grade highway-rail crossings. Some existing at-grade highway-rail crossings may be closed (blocked off) as a part of the Project. The Project would also involve culvert replacements and extensions, utility replacements and relocations, and implementation of safety warning devices. Passenger rail service would occur from five stations located at E Street and Tippecanoe Avenue in the City of San Bernardino and New York Street, Orange Street (Downtown Redlands), and University Street (University of Redlands) in the City of Redlands. The station platforms at E Street would be constructed as part of a separate project that would extend Metrolink service east from the Santa Fe Depot.

The selected Project alternatives would be constructed within the corridor identified in Figure 2, RPRP Study Area. SANBAG proposes the construction of a single track with a one-mile long passing siding located near the midpoint of the alignment. Project components would include the following with construction planned to start in 2015:

- Track Improvements. Proposed track improvements include a redesign of the existing single track alignment and track ballast and subgrade foundation from E Street in San Bernardino to Cook Street in Redlands. Existing rail and railroad ties will be salvaged as part of the Project.
- E Street, Tippecanoe Avenue, New York Street, Downtown Redlands, and University of Redlands Rail Stations. The proposed rail stations will include the installation of new station boarding platforms (with the exception of the E Street Station), ticket vending machines, a shade canopy with some seating, accessible walkways to the public ROW or parking area, lighting, and parking area(s).
- Grade Crossings. Twenty-eight existing highway-rail at-grade crossings and two existing grade separated crossings are within the limits of the project and may be modified to improve and update the safety warning systems at each crossing. Some crossings may be closed to improve roadway related safety associated with the Project. The two existing grade separated crossings of Interstate Route 10 (I-10) will remain.

- Parcel Acquisitions and Relocations. Acquisition of additional ROW is required. At this time, SANBAG is not certain of the number of affected parcels as the project is currently in preliminary design phases. In some instances, the acquired parcels may contain active businesses requiring relocation.
- Culvert Replacements, Extensions, and Relocations. Drainage facilities along the rail corridor, such as culverts that extend under the existing railroad track, will require replacement, extension, or relocation. New culverts may be added to improve drainage across (under) the rail corridor.
- Utility Replacement and Relocation. Storm drains, sewer lines, water lines, under drains, railroad signal houses, street lights, power poles and conductors, telephone and/or fiber optic communications lines, commercial billboards, and an oil line will require replacement, relocation, or extension.
- Traffic and Rail Signals. Additional rail and traffic signals will be installed for the corridor based on the final project design. The new passenger rail system will operate under Automatic or Centralized Traffic Control with a single passing siding. A new communications fiber optic backbone communications line will be constructed within the railroad corridor.
- Rail Operations. An operating plan has been developed using Rail Traffic Controller modeling and operational analysis based on input from SANBAG, Metrolink, and BNSF. Operations are projected to commence in 2018. Passenger rail service would utilize previously-owned rail vehicles consisting of a single trainset composed of one locomotive and up to two cars.
- Maintenance. Typical railroad maintenance will be required during the operational phase of the project and would be completed from a centralized layover facility proposed to the west of California Street; immediately south of I-10.

The EIR/EA will include consideration of alternatives to the Project consistent with the requirements of California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA). At this time, SANBAG anticipates that this may include the consideration of a No Project/Action Alternative and an Alternative Layover Facility Location. Other build alternatives may also be considered.

The potential environmental effects of the project include, but are not limited to, the following: aesthetics, air quality/greenhouse gases, biological resources, cultural resources, hazards and hazardous materials, hydrology and water quality, land use and planning, noise, acquisitions/displacements, environmental justice, and transportation/circulation. These topics will be analyzed in the EIR/EA.

1.7. Other Stakeholders

Other stakeholders, both public and private, that are involved from a stormwater quality perspective are City of San Bernardino, City of Redlands, Caltrans, ESRI, SBCFCD and University of Redlands. ESRI, a private company, is involved as they are financing the construction and maintenance of the New York station and surrounding applicable improvements. The nexus for the stakeholders' involvement is identified in the document herein.

1.8. Drainage System

1.8.1. Watershed Background

The Project is located in the Santa Ana Watershed and is divided by the SAR, the mainstem, at approximate MP 3.4. This corresponds to SAR River Mile 28.62 (approximate) and is part of System No. 2-701-1A (SBCFCD System Index, January 2010). Specifically located within the Upper Santa Ana Watershed, the SAR divides the project into the north/west segment (3.4 miles, 34 %) and the south/east segment (6.6 miles, 66 %), with each side draining tributary onsite and offsite areas into the SAR either by surface flow, local drainage facilities, or major stormwater conveyance systems. The project is tributary to Reach 4 (downstream - minority) and Reach 5 (upstream - majority) of the SAR. See Figure 3 in Appendix A.

The Project is located in SBCFCD Flood Control Zones 2 (318 square miles) and 3 (366 square miles) with the boundary between these zones lying along the SAR. Zones 2 and 3 lie west and east of the SAR and correspond to the north/west and south/east segment of the project, respectively. From this point forward in the document, the north/west and the south/east segment of the tributary drainage of the project will be referred to as the Zone 2 Drainage Area (Z2DA) and Zone 3 Drainage Area (Z3DA), respectively. Within the project, the major stormwater conveyance systems that cross or are adjacent to the project are Warm Creek (Historic), Twin Creek, SAR, Mission Zanja Creek, and Mill Creek Zanja. The Z2DA and the Z3DA are part of the Warm Creek/Twin Creek and Zanja basins, respectively. Portions of City of San Bernardino and City of Redlands are located in both zones. Beside SBCFCD, related drainage infrastructure tributary to the project is also under the jurisdiction of City of San Bernardino, City of Redlands, Caltrans USACE.

Within the Z2DA, the westerly drainage area flows to Warm Creek (Historic) [part of Subarea J which is part of the below report] and outlets to Warm Creek via the Warm Creek Bypass Channel. This part of Z2DA is tributary to Reach 4 of the SAR. Second, the easterly drainage area flows to the East Twin Creek and Warm Creek Channel (also known as Twin Creek) [part of Subarea M which is part of the below report] and outlets to Reach 5 of the SAR. The small remainder of the Z2DA south of the above drainage area surface flows directly to Reach 5 of the SAR. The Z2DA lies entirely within the City of San Bernardino (USACE, Review Report, Lytle and Warm Creek).

Similarly, the drainage from the Z3DA is part of the Zanja drainage basin (26 square miles) and is located in the County of San Bernardino, City of San Bernardino, and City of Redlands. The basin flows westward for about 12 miles until it confluences with Reach 5 of the SAR. The mainstem of the Zanja drainage basin is the Zanja Creek which is the principal flood control facility for the City of Redlands. In various historical and technical documents, the Zanja Creek is also referred to as Mission Zanja Creek, Mission Channel, Mill Creek Zanja, Sylvan Creek (per railroad documentation) and the Zanja.

The Zanja Creek consists of three segments. The Creek is a partially improved open channel from the SAR to 1st Street (City of Redlands) and is referred to as the Mission Zanja Channel. The Creek continues upstream under downtown Redlands from 1st Street to 9th Street (City of Redlands) as the Mission Storm Drain. Finally, the Mill Creek Zanja is the upstream segment of the Creek system and extends from 9th Street to the Mill Creek confluence at the upstream (east) end (San Bernardino County).

The project is under the jurisdiction of the Santa Ana RWQCB, Region 8 for water quality issues. The Santa Ana Watershed is divided into Hydrologic Areas (HA) that are subdivided into Hydrologic Sub Areas (HSA). According to the Basin Plan of the Santa Ana RWQCB, the project is located within the Upper SAR HA 801.50; specifically HSA 801.52 (Bunker Hill) and 801.53 (Redlands) on the west and east end of the project, respectively, with the HSA boundary at approximately New York Street in the City of Redlands. However, the northern/western end of the project (from Mill Street north – City of San Bernardino) drains to Colton HSA 801.44 (part of Colton-Rialto HA 801.40) by way of the Warm Creek Bypass and Lytle Creek Channels which confluences with the SAR in Reach 4. The SAR transitions from Reach 5 to Reach 4 at the San Jacinto Fault, just southwest of the project area, which is the boundary between Bunker Hill HSA and Colton HSA. Reach 4 is defined as the portion of the SAR from Mission Boulevard in Riverside to the San Jacinto Fault in San Bernardino. The remainder of the project, from Twin Creek (MP 2.2) to University of Redlands (MP 10.0), drains to Reach 5 and is associated with HSA 801.52 (Bunker Hill) and 801.53 (Redlands).

1.8.2. Local Drainage

Onsite drainage is storm runoff generated within the project's existing ROW limits. In contrast, offsite drainage is storm runoff that originates outside of the existing railroad ROW, but tributary to the project site either by way of surface and/or subsurface conveyance. However, once onsite and offsite drainage is collected in an onsite system, it will discharge to either an existing or proposed local storm drain system, or modification thereof, or an existing major flood control facility. Local drainage consists of either public water or private water and may comingle depending on its location. Local storm drain systems are under the jurisdiction of

City of San Bernardino, City of Redlands or Caltrans. Drainage along I-10, from the West I-10 Overpass to the East I-10 Overpass, is part of the offsite drainage tributary to the project at various locations. Caltrans has jurisdiction over the I-10 drainage (SANBAG, Preliminary Hydrology & Hydraulics Study).

1.8.3. Major Flood Control Facilities

A total of five major flood control facilities either cross or are located longitudinally to the project. The crossings from west to east are known as Warm Creek (Historic) [Bridge 1.1], Twin Creek [Bridge 2.2], Santa Ana River [Bridge 3.4], and Mill Creek Zanja [Bridge 9.4]. Mission Zanja Channel is the one major offsite facility located adjacent to a segment of the project (Mile Post (MP) 3.4 to 6.1). The numbers associated with the bridge designations correspond to the railroad Mile Post. See Figure 3. The table below summarizes the existing major flood control facilities discussed above.

Table 1-1. Existing Major Flood Control Facilities

Name	Mile Post	Jurisdiction	Q100 (cfs)	Description
Warm Creek (Historic)	1.1	City of San Bernardino	2,525 cfs	17 ft wide by 9 ft high RCC
Twin Creek	2.2	SBCFCD, Zone 2	22,000 cfs SPF*	60 ft wide by 14 ft high RCC
Santa Ana River	3.4	SBCFCD, Zone 2 & 3	67,000 cfs	Unimproved trapezoidal channel
Mill Creek Zanja (aka Sylvan Creek)	9.4	City of Redlands	3,000 – 4,000 cfs	Unimproved channel, no fixed geometry
Mission Zanja Channel	3.4 to 6.1	SBCFCD, Zone 3	1,000 – 6,000 cfs	Unimproved trapezoidal channel

The stormwater runoff from these facilities are considered project run-on for purposes of this document. For additional information, refer to the Preliminary H&H Study and the Floodplain Evaluation Technical Memorandum.

1.8.4. Coordination with Impacted Planned/Designed Projects

Arrowhead Parking Lot (MP 1.3)

Ludwig Engineering is contracted with the City of San Bernardino to provide final engineering plans for a proposed temporary parking lot at the southeast corner of Rialto Avenue and Arrowhead Avenue, which is adjacent to the north side of the RPRP in the City of San Bernardino. The purpose of the lot is to provide temporary parking for the construction workers of the new Justice Center at 3rd Street and Arrowhead Avenue. The Justice Center is under construction and is scheduled to last approximately two years and should be completed by March 2014. Once the Justice Center is completed, the temporary parking lot will be removed and the parcel will be restored to its original condition (City of San Bernardino, March/May, 2012).
The proposed parking lot will be paved and will consist of a 351-foot long by 62-foot wide by 0.5-foot (minimum) high detention basin located in the northwest portion of the temporary parking lot to which the entire lot will drain. The basin will outlet to an existing 12-inch diameter storm drain at the southeast corner of Rialto Avenue and Arrowhead Avenue. A proposed 2:1 slope embankment will be constructed along the north railroad ROW to separate the railroad offsite flows from the project flows. In the existing condition, the parcel drains to a low point just north of the south property line and about 150 feet east of the west property line. The north side of RPRP also drains to this low point. This basin will also serve for water quality treatment in accordance with the project WQMP.

I-10 HOV Widening Project (MP 5.61/9.45)

http://www.sanbag.ca.gov/projects/mi_fwy_I-10-HOV.html

SANBAG is working with Caltrans to prepare a project report and environmental document to add a carpool lane, also known as an express lane or HOV lane, in each direction of I-10 between Haven Avenue (PM 8.20) in Ontario and Ford Street (PM 33.43) in Redlands, a 25-mile span. The I-10 HOV project will extend the carpool lanes east from where the existing carpool lanes end. In addition to the carpool lanes, the project proposes to widen outside existing lanes, pave medians, widen several existing under-crossings, rebuild over-crossings where needed, construct a concrete median barrier, improve drainage and add auxiliary lanes to improve weaving between on-ramps and off-ramps.

As part of the Project Approval and Environmental Documentation (PA&ED) phase, Parsons Transportation Group (PTG) is evaluating several alternatives for the project under contract with SANBAG. SANBAG estimates that the PA&ED will be approved by 2017. Final design and acquisition of ROW is tentatively set to be approved and certified by 2014. If funds are available, construction could start by 2015, and

portions of the project could be completed by 2020. This schedule is based on funding availability and subject to change.

As discussed in Section 1.8.2, some of the onsite and offsite drainage along I-10 is conveyed across or along the RPRP via pipes and lined/unlined ditches.

The Water Resources and Water Quality Technical Report (WRWQTR) assesses potential impacts to surface waters, groundwater, flooding, water quality, and designated beneficial uses that could result from the proposed construction and operation of the I-10 HOV Widening project.

During the preliminary project design, various Treatment BMPs were assessed to determine their applicability to the proposed project based on identified site-specific pollutants, project design features, and site conditions, including available ROW. With the implementation of Construction Site BMPs, Design Pollution Prevention BMPs, and Treatment BMPs, the effects to water quality associated with the construction and operation of the proposed project would be less than significant. In conclusion, the I-10 HOV Lane Addition Project would not result in significant effects to water resources or water quality.

The WRWQTR identifies various proposed BMPs along the I-10 HOV Widening Project. The closes one to the project is BMP 39, which is located on south side of the I-10 low point between the West I-10 Overpass (Mission Zanja Channel crossing) and California Street in the City of Redlands. Proposed BMP 45, located at the northeast corner of I-10 and Orange Street, is identified as treating the freeway drainage from University Street west to Orange Street in the City of Redlands, including the East I-10 Overpass (Mill Creek Zanja crossing).

Similarly, a Storm Water Data Report (SWDR) was prepared for the project which is a Caltrans document that summarizes the stormwater quality issues from a technical standpoint, and is normally coordinated with the WRWQTR. The SWDR identifies BMP 39 as a proposed bioswale (I-10 station 1310+00 right), and BMP 45 as a proposed infiltration basin, detention basin, or media filter (I-10 station 1474+00 left).

Mountain View Avenue Street Improvements (MP 5.2)

In 2006, Inland Valley Development Agency (IVDA) awarded a contract to T.Y. Lin for professional services to design improvements for Mountain View Avenue from Palm Meadows Drive/Central Avenue to I-10. The project is currently designed to be constructed in two phases. The first phase (design completed) will consist of the bridge structure over the SAR and includes road and infrastructure improvements southbound to Riverview Avenue/San Bernardino Avenue. The second phase of the project (design 95 percent complete) will complete the road improvements from

Riverview Avenue/San Bernardino Avenue southbound to the I-10 interchange and includes a second, smaller bridge structure at the Mission Zanja Creek crossing (culvert to convey Creek flows). Phase 1 construction began in October 2012 with Phase 2 planned to commence construction shortly thereafter. Both phases are scheduled to be completed by 2013.

The project drains from south to north along the street; specifically, from I-10 to Mission Zanja Creek, and from Mission Zanja Creek north to SAR. Drainage from the southern portion will be intercepted at a sump by a proposed catch basin just south of Mission Zanja Creek, then will be intercepted by an existing 69-inch RCP, and enter stormwater treatment devices (BMPs) before it is discharged to Mission Zanja Channel. The BMPs consist of two Contech StormFilter vaults utilizing cartridges and related details are reflected in the project WQMP.

Redlands Boulevard/Alabama Street Intersection Improvements

http://www.cityofredlands.org/redlandsalabamaintersection

The City of Redlands has contacted with Parsons Brinckerhoff to provide an engineering design to the Redlands Boulevard, Alabama Street, and Colton Avenue Street Improvement project. The project is intended to improve traffic flow to two Redlands Boulevard intersections – at Alabama Street and at Colton Avenue. Currently, the schedule for approval of the related environmental document and securing funding are unknown. This current City project intersects the RPRP at Colton Avenue and Alabama Street. Water quality treatment to tributary offsite City drainage approaching these two streets will be addressed in the project WQMP.

University of Redlands (UOR) Center for the Arts Infiltration Basin

The UOR constructed improvements at the Center for the Arts in 2008 which included an infiltration basin for purposes of water quality. These improvements front Park Avenue and are adjacent to University Street on the east. The infiltration basin, owned by UOR, is adjacent to the RPRP and close to the proposed UOR station. During PS&E phase, there might be an opportunity to mitigate for added runoff volume and water treatment from the proposed UOR station. This will require coordination with the UOR and the associated project-approved WQMP.

1.9. Existing Conditions

In its current state, the RPRP does not include any structural devices that function as BMPs for storm water quality. Typical of railroads, the mainline includes side ditches that may be considered as soft non-structural BMP features that drain and infiltrate railroad runoff mostly for the low intensity storms. Similarly, the railroad permeable ballast serves to infiltrate runoff and provides some level of treatment from the

underlying soil. The Project does not include impermeable surfaces such as pavements (0 acres) except for those areas at grade crossings that are asphalt paved.

1.10. Proposed Conditions

The Project proposes drainage improvements such as earth ditches, concrete-lined ditches, culverts, perforated underdrain systems, and limited storm drains along the rail ROW. Of these, the earth ditches and underdrain systems will provide some level of treatment by the underlying soil. The impervious area of the Project is proposed to be approximately 21 acres, and includes pavements at the platforms, parking lots, and layover facility in addition to the concrete-lined ditches. Furthermore, the soil disturbance area ranges from 129 to 144 acres. The impervious area and soil disturbance area will be further refined during the PS&E phase.

1.11. Drinking Water Reservoir and/or Recharge Facilities

There are no current drinking water reservoirs or recharge facilities in the Project. According to the California Department of Water Resources, there are 17 wells near the Project. The depth to groundwater ranges from 0.2 to 149.4 feet, and the corresponding elevation ranges from 940.9 to 1022.8 feet. Based on Project geotechnical field data, the groundwater depth ranges from 33 feet to 96 feet, and the corresponding elevation ranges from 920.5 to 1080 feet (SANBAG, Geotechnical Report).

1.12. Geotechnical

As of the preparation of this report, the draft geotechnical report is still forthcoming. Once the draft geotechnical report is available, this section will be summarized.

1.13. Groundwater

The groundwater management agency in the City of San Bernardino and City of Redlands that overlays the project is the San Bernardino Valley Municipal Water District (SBVMWD) which is the wholesaler of potable water to the area. SBVMWD sells water to the local retailers, City of San Bernardino Water Department and City of Redlands Water Department. The project is overlaid by these two retailers.

It will be determined during PS&E if infiltration basins will be used as BMPs for the Project. If infiltration basins are proposed, concurrence will be sought from SBVMWD to consider the use of infiltration basins consistent with Section XI.E.3 of the permit order R8-2010-0036.

1.14. Construction Phase Risk Level

The CGP requires construction BMPs to be implemented for virtually all projects in the state. All traditional construction projects that disturb 1 acre or more must apply for CGP coverage. Since the soil disturbance area ranges from 129 to 144 acres and falls into the traditional project category, the project will be required to comply with the CGP during the construction phase.

The CGP follows a risk-based permitting approach. Each project is evaluated for *sediment discharge risk* and *receiving water risk*. These factors combine to determine the project Risk Level (1, 2, or 3) according to tables in the CGP (i.e., Risk Level 1 is the lowest risk and Risk Level 3 is the highest risk). Permit requirements progressively increase with risk level as identified in the CGP. Some of those permit requirements based on risk are related to minimum BMPs, Numeric Action Levels, Numeric Effluent Limitations, Visual Monitoring, Runoff Monitoring, and Receiving Water Monitoring. Another significant change to this permit is identification of the Legally Responsible Person (LRP). The LRP is generally the entity with real estate interest that is associated with the project being proposed for construction. In this case, the LRP is SANBAG and they are ultimately responsible for compliance with the CGP.

There are two aspects involved in developing a risk determination analysis for a specific project site. The first is to determine the Sediment Risk which involves an R-factor (rainfall erosivity), K-factor (soil erodibility) and LS-factor (topographic). The second is to determine the Receiving Water Risk which involves the impact runoff will have on the receiving water body. Combining these two Risks in a table will determine the overall Risk Level for the project. See Appendix F for determination of construction risk level.

Sediment Risk

There are two approaches for determining the sediment risk level according to the CGP; Geographic Information System (GIS) Map method or Site-Specific Information method. This analysis was based on GIS Map information. The sediment risk is based upon the Revised Universal Soil Loss Equation (RUSLE) equation with the three aforementioned factors and is separated into three risk level categories; < 15 tons/acre (low), >15 and <75 tons/acre (medium) and >75 tons/acre (high).

The R-factor is based upon the location and duration of construction. The location used to determine the R-factor was determined using Google Earth. It is anticipated that the construction schedule will begin January 1, 2015, and end on December 31, 2017. The resultant R-factor is 120. Based on the GIS data available from the SWRCB, Google Earth reflected the K-factors for the project to vary from 0.2 to 0.24; a rounded value was used. Hence, the resultant K-factor is 0.2. Based on the GIS data

available from the SWRCB, Google Earth reflected the LS-factors to vary from west to east as 1.19, 1.98, 0.99, and 0.82. To be conservative, an average LS-factor of 1.3 is assumed. Based on the aforementioned factors, the Project's Sediment Risk is computed to be 31.2 tons/acre and is categorized as *Medium*.

Receiving Water Risk

The Project discharges to the SAR Reaches 4 and 5. According to the 2006 303(d) List and the 2010 Integrated Report, the SAR Reaches 4 and 5 is not a water body that is impaired by sediment. This was also confirmed by the SWRCB GIS map data on Google Earth. In addition, the receiving water body's designated Beneficial Uses does not include SPAWN, COLD and MIGATORY. Since both of these criteria do not pertain to the Project the resultant Receiving Water Risk is *Low*.

Overall Project

Based on the Sediment Risk and Receiving Water Risk categories, the entire Project is categorized as a combined ***Risk Level 2***.

1.15. Regulatory Setting

The purpose of this section is to discuss the regulatory framework of the project as it applies to stormwater quality and its impacts with an emphasis on post-construction phases. The discussion will include Federal, State, Regional, and Local levels.

1.15.1. Federal

1.15.1.1. Federal Water Pollution Control Act (Clean Water Act, or CWA)

In 1972, the Federal Water Pollution Control Act (also referred to as the Clean Water Act, or CWA) was amended to provide that the discharge of pollutants to waters of the United States from any point (such as discharge from an industrial facility) or non-point (surface and farmland water runoff) source is unlawful unless the discharge is in compliance with an NPDES permit. In November 1990, the U.S. Environmental Protection Agency (USEPA) published final regulations that established stormwater permit application requirements for specified categories of industries.

The CWA was enacted with the intent of restoring and maintaining the chemical, physical, and biological integrity of the waters of the United States. The CWA requires states to set standards to protect, maintain, and restore water quality through the regulation of point source pollution and certain non-point source discharges to waters of the U.S. Those discharges are regulated by the NPDES permit process (CWA Section 402). In

California, NPDES permitting authority is delegated to, and administered by, the nine RWQCBs.

Section 303(d) and Total Maximum Daily Loads (TMDLs). Section 303(d) of the CWA bridges the technology-based and water quality-based approaches for managing water quality. Section 303(d) requires that states compile a list of waters that are not attaining standards after the technology-based limits are enacted. For waters on this list, the states are to develop TMDLs. TMDLs are established at the level necessary to implement applicable water quality standards. A TMDL must account for all sources of pollutants that cause the water to be listed. Federal regulations require that TMDLs, at a minimum, account for contributions from point sources and nonpoint sources.

1.15.1.2. U.S. Environmental Protection Agency (USEPA)

The USEPA is the federal agency responsible for water quality management and administration of the CWA. The USEPA has delegated most of the administration of the CWA in California to the SWRCB. Much of the responsibility for implementation of the SWRCB's policies is delegated to the RWQCB, as described below. USEPA conducts groundwater protection and contaminated site remediation programs, such as installation of groundwater cleanup systems.

1.15.1.3. NPDES

The goal of the NPDES diffuse source regulations is to improve the quality of stormwater discharged to receiving waters to the "maximum extent practicable" through the use of BMPs. The NPDES permit system was established in the CWA to regulate point source discharges (a municipal or industrial discharge at a specific location or pipe) and certain types of diffuse source dischargers. As defined in the federal regulations, nonpoint sources are generally exempt from federal NPDES permit program requirements. Nonpoint pollution sources are diffuse and originate over a wide area rather than from a definable point. Nonpoint pollution often enters receiving water in the form of surface runoff and is not conveyed by way of pipelines or discrete conveyances. Urban stormwater runoff and construction site runoff, however, are diffuse-sources regulated under the NPDES permit program because they discharge to receiving waters at discrete locations in a confined conveyance system. Sections 401 and 402 of the CWA contain general requirements regarding NPDES permits. For diffuse-source discharges (e.g., municipal stormwater and construction runoff), the NPDES program establishes a comprehensive stormwater quality program to manage urban stormwater and minimize pollution of

the environment to the maximum extent practicable. The NPDES program consists of (1) characterizing receiving water quality, (2) identifying harmful constituents, (3) targeting potential sources of pollutants, and (4) implementing a Comprehensive Stormwater Management Program. State implementation of the NPDES program as it relates to the proposed project is discussed below under state and regional regulations.

Direct discharges of pollutants into waters of the United States are not allowed, except in accordance with the NPDES program established in Section 402 of the CWA. The main goal of the NPDES program is to protect human health and the environment. Pursuant to the NPDES program, permits that apply to stormwater discharges from municipal storm drain systems, specific industrial activities, and construction activities that disturb 1 acre or more have been issued. NPDES permits establish enforceable effluent limitations on discharges, require monitoring of discharges, designate reporting requirements, and require the permittee to perform BMPs. Industrial (point source) storm water permits are required to meet effluent limitations. Municipal permits are governed by the Maximum Extent Practicable (MEP) or the Best Available Technology Economically Achievable (BAT)/Best Conventional Pollution Control Technology (BCT) application of BMPs.

1.15.2. State

1.15.2.1. SWRCB

As described above, the EPA has delegated most of the administration of the CWA in California to the SWRCB. In turn, much of the responsibility for the implementation of the SWRCB's policies is delegated to the nine RWQCBs. The nine RWQCBs develop and enforce water quality objectives and implementation plans. The SWRCB establishes statewide policies and regulations for the implementation of water quality control programs mandated by federal and state water quality statutes and regulations. The RWQCBs develop and implement Water Quality Control Plans (Basin Plans) that consider regional beneficial uses, water quality characteristics, and water quality problems. In cases where the Basin Plan does not contain a standard for a particular pollutant, other criteria are used to establish a standard.

Section 401 of the CWA requires water quality certification from the SWRCB or from a RWQCB when a project requires a CWA Section 404 permit. Section 404 of the CWA requires a permit from the USACE to discharge dredged or fill material into waters of the United States.

Section 303(d) of the CWA requires the SWRCB to list impaired water bodies in the state and determine total maximum daily loads (TMDLs) of pollutants or other stressors that are contributing excessively to these impaired waters. SWRCB is also responsible for granting water rights permits, approving water right transfers, investigating violations, and may reconsider or amend water rights.

1.15.2.2. California Department of Toxic Substances Control (DTSC)

DTSC is responsible for oversight of hazardous substances and remediation of contaminated sites, including water sources in some cases.

To fill in the gap between the water quality control plans and CWA requirements, on May 18, 2000, the USEPA promulgated the California Toxics Rule based on the Administrator's determination that numeric criteria are necessary in the State of California to protect human health and the environment. These federal criteria are numeric water quality criteria for priority toxic pollutants and other provisions for water quality standards legally applicable in the State of California for inland surface waters, enclosed bays, and estuaries for all purposes and programs under the CWA.

1.15.2.3. California Department of Fish and Game (CDFG)

CDFG has jurisdiction over conservation and protection of fish, wildlife, plants, and habitat. Through provisions of California Fish and Game Code Section 1602, CDFG is empowered to issue agreements for any alteration of a river, stream, or lake where fish or wildlife resources may be adversely affected. CDFG determines stream flow requirements in certain streams, acts as permitting agency for streambed alterations, and enforces the California Endangered Species Act.

The California Fish and Game Code Section 1602 requires any person, State or local governmental agency, or public utility to notify the CDFG before beginning any activity that will result in one or more of the following: (1) substantially obstruct or divert the natural flow of a river, stream, or lake; (2) substantially change or use any material from the bed, channel, or bank of a river, stream, or lake; or (3) deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it can pass into a river, stream, or lake. California Fish and Game Code Section 1602 applies to all perennial, intermittent, and ephemeral rivers, streams, and lakes in the State.

1.15.2.4. Porter Cologne Water Quality Control Act

The Porter Cologne Water Quality Control Act of 1967 (Water Code Section 13000 et seq.) establishes a regulatory program to protect water quality and to protect beneficial uses of State waters. It empowers the SWRCB and the nine RWQCBs to formulate and adopt, for all areas within the regions, Basin Plans that designates beneficial uses and establish such water quality objectives that in its judgment will ensure reasonable protection of beneficial uses. Each RWQCB establishes water quality objectives that will ensure the reasonable protection of beneficial uses and the prevention of nuisance. The California Water Code provides flexibility for some change in water quality, provided beneficial uses are not adversely affected.

The Porter-Cologne Water Quality Control Act authorizes the State boards to adopt, review, and revise policies for all waters of the state (including both surface and ground waters).

1.15.2.5. NPDES CGP

On September 2, 2009, the California SWRCB adopted the current NPDES General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities, Order No. 2009-0009-DWQ, NPDES No. CAS000002, otherwise known as the CGP. The 5-year cycle permit became effective on July 1, 2010, and is expected to expire by September 2, 2014. The CGP has since been amended twice. As a result of the latest amendment, the Numeric Effluent Limitations (NELs) for pH and turbidity at Risk Level 3 and LUP Type 3 construction sites contained in Order 2009-0009-DWQ are no longer in effect. In addition, receiving water monitoring requirements are also suspended at this time.

In accordance with NPDES regulations, the State of California requires that any construction activity disturbing 1 acre or more of soil comply with the Construction General Permit. To obtain authorization for proposed storm water discharges pursuant to this permit, the landowner (discharger) is required to submit Permit Registration Documents, including a risk assessment, site map, Storm Water Pollution Prevention Plan (SWPPP), annual fee, and signed certification statement to the SWRCB. Dischargers are required to implement BMPs meeting the technological standards of BAT and BCT to reduce or eliminate storm water pollution. BMPs include programs, technologies, processes, practices, and devices that control, prevent, or remove or reduce pollution. Permittees must also maintain BMPs and conduct inspection and sampling programs as required by the permit. Dischargers are also required to comply with monitoring and reporting requirements to ensure that discharges comply with the numeric

action levels and numeric effluent limitations specified in the permit. The proposed project is subject to the requirements of the Construction General Permit because it would disturb more than 1 acre of soil during construction. For more information see the State Water Board Storm Water page: http://www.swrcb.ca.gov/water_issues/programs/stormwater/construction.shtml.

1.15.2.6. NPDES IGP

In 1997, the California SWRCB adopted the current National Pollutant Discharge Elimination System (NPDES) General Permit for Waste Discharge Requirements for Discharges of Storm Water Associated with Industrial Activities Excluding Construction Activities, Order No. 97-03-DWQ, NPDES No. CAS000001, otherwise known as the IGP. The permit became effective in 1997 and has been administratively extended until the renewed permit is adopted. A draft of the renewed permit has been issued for public release. At the earliest, the renewed permit is expected to be adopted in 2013.

In accordance with NPDES regulations, the State of California requires that storm water associated with industrial activity (storm water) that discharges either directly to surface waters or indirectly through municipal separate storm sewers must be regulated by an NPDES permit. USEPA developed a four-tier permit issuance strategy for storm water discharges associated with industrial activity (e.g., Tier I to Tier IV). The regulations allow California, as an authorized state, to issue general permits or individual permits to regulate storm water discharges.

This General Permit generally requires facility operators to

1. Eliminate unauthorized non-storm water discharges;
2. Develop and implement a SWPPP; and
3. Perform monitoring of storm water discharges and authorized non-storm water discharges.

The IGP is intended to cover all new or existing storm water discharges and authorized non-storm water discharges from facilities required by Federal regulations to obtain a permit. As such, the project will include facilities, such layover yards, whose storm water discharge will meet permit requirements and is associated with Category 8, “Transportation facilities that conduct any type of vehicle maintenance such as fueling, cleaning, repairing, etc.” For more information see the State Water Board Storm Water, Industrial General Permit page:

http://www.swrcb.ca.gov/water_issues/programs/stormwater/gen_indus.shtml#indus

1.15.3. Regional

1.15.3.1. Santa Ana Region Basin Plan (Basin Plan)

The project site is within the jurisdiction of the Santa Ana RWQCB. The Santa Ana RWQCB provides permits that affect surface waters and groundwater. Under Section 303(d) of the CWA, the Santa Ana RWQCB is also responsible of the CWA for protecting surface waters and groundwater from both point and non-point sources of pollution within the project site and for establishing water quality standards and objectives in its Basin Plan that protect the beneficial uses of various waters. The State has developed TMDLs, which is a calculation of the maximum amount of a pollutant that a waterbody can have and still meet Water Quality Objectives (WQOs) established in the Basin Plan, in order to protect the valuable uses of its waters.

1.15.3.2. General Waste Discharge Requirements for De Minimis Discharges

On March 27, 2009, the Santa Ana RWQCB adopted the General Waste Discharge Requirements for Discharges to Surface Waters that Pose an Insignificant (De Minimus) Threat to Water Quality (Order No. R8-2009-0003, NPDES No. CAG998001). This permit covers discharge of groundwater and non-storm water construction dewatering waste in the Santa Ana region. For coverage under this permit, a discharger is required to submit a Notice of Intent to the Santa Ana RWQCB. Under this permit, discharges must comply with discharge specifications, receiving water limitations, and monitoring and reporting requirements detailed in the permit. The Project is not subject to the requirements of the De Minimus Permit because groundwater and other non-storm water discharge are not anticipated during construction.

1.15.3.3. SCAG Regional Transportation Plan (RTP)

Southern California Association of Governments (SCAG) is the federally designated Metropolitan Planning Organization (MPO) under for the six-county region that includes the counties of Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura. SCAG is required to prepare a RTP and pursuant to State Government Code. The State requirements largely mirror the federal requirements and require each Regional Transportation Planning Agency (RTPA) in urban areas to adopt and submit an updated

RTP to the California Transportation Commission (CTC) and the California Department of Transportation (Caltrans) every four years.

The purpose of the 2012-2035 RTP/Sustainable Communities Strategy (SCS) is to provide a clear, long-term vision of the regional transportation goals, policies, objectives and strategies for the SCAG region while at the same time providing strategies to reduce greenhouse gas emissions as required by Senate Bill (SB) 375. The 2012-2035 RTP/SCS is a long-range Regional Transportation Plan that includes projects, policies, and strategies to create a blueprint for the region's growth through 2035. The Plan includes improvements to the transportation system and is intended to meet the changing socioeconomic, transportation infrastructure, financial, technological and environmental conditions of the region. On April 4, 2012, SCAG adopted the 2012-2035 RTP/SCS.

Impacts to water resources from the 2012–2035 RTP/SCS include potential water quality impairment from increased impervious surfaces. Increased impervious surfaces in water recharge areas potentially impact groundwater recharge and groundwater quality. Cumulative impacts include increased impervious surfaces; increased development in alluvial fan floodplains; and increased water demand and associated impacts, such as drawdown of groundwater aquifers. These impacts can occur at the localized scale and in relation to existing conditions, as the Plan itself does not affect the total amount of growth in the region. Increased output of greenhouse gases from the region's transportation system impacts the security and reliability of the imported water supply.

The water resources mitigation program includes, but is not limited to, the following types of example measures:

- Utilizing advanced water capture and filtration techniques, showing a preference for naturalized systems and designs, to control stormwater at the source;
- Avoiding any new construction of impervious surfaces in non-urbanized areas, such as wetlands, habitat areas, parks, and near river systems;
- Avoiding any new construction that provides access to flood-prone areas, such as in alluvial fans and slide zones;
- Protection and preservation of existing natural flood control systems, such as wetlands and riparian buffers, and expansion of such systems in areas where they do not currently exist;

- Constructing projects according to Best Management Practices for water quality protection and water conservation, including low-impact development and green building standards; and
- Coordinating project development and construction efforts across jurisdictional, agency, and departmental boundaries, to increase project benefits.

As part of this process, the related Final Program EIR was approved. The EIR describes the current water resources in the SCAG region, discusses the potential impacts of the 2012-2035 RTP/SCS on water resources, identifies mitigation measures for the impacts, and evaluates the residual impacts.

1.15.4. Local

1.15.4.1. San Bernardino County NPDES MS4 Permit, Santa Ana Region

The Cities of San Bernardino and Redlands are co-permittees under the NPDES Permit and Waste Discharge Requirements for the San Bernardino County Flood Control District, the County of San Bernardino, and the Incorporated Cities of San Bernardino County within the Santa Ana Region, Order No. R8-2010-0036 (NPDES No. CAS618036). The NPDES permit prohibits discharges, sets limits on pollutants being discharged into receiving waters, and requires implementation of technology-based standards.

Under the NPDES permit, the respective Cities as co-permittees are responsible for the management of storm drain systems within their jurisdiction. Cities are required to implement management programs, monitoring programs, implementation plans, and all BMPs outlined in the Municipal Storm Water Management Program (MSWMP) (previously identified as the Drainage Area Management Plan (DAMP) in the County's two prior NPDES permits) and to take any other actions as may be necessary to protect water quality to the MEP. In addition, each city is required to implement a MSWMP and develop a long-term assessment strategy for effectiveness of the MSWMP.

Category Projects within the City are required to develop and implement Water Quality Management Plans (WQMPs) to reduce pollutants and maintain and reduce downstream erosion and stream habitat from all new development and significant redevelopment projects that fall into one of the categories of priority projects. The co-permittees must ensure that a Category Project meets WQMP requirements. Category Projects include significant redevelopment projects that create 5,000 square feet or more

of impervious surface, home subdivisions of 10 units or more, industrial/commercial developments of 100,000 square feet or more, automotive repair shops, restaurants of 5,000 square feet or more, hillside developments of 10,000 square feet or more, developments of 2,500 square feet of impervious surface or more adjacent to or discharging directly into environmentally sensitive areas, or parking lots of 5,000 square feet or more. In addition, Non-Category Projects that have a precise plan of development (e.g., all commercial or industrial projects, residential projects <10 dwelling units, and all other land development projects with potential for significant adverse water quality impacts) or subdivision of land must prepare and implement a WQMP. San Bernardino County has prepared a Model Water Quality Management Plan Guidance document for preparation of project-specific WQMPs. The Model Water Quality Management Plan Guidance document was approved by the Santa Ana RWQCB on April 30, 2004, and updated on January 17, 2012.

SANBAG or BNSF is not a co-permittee of the NPDES permit; however, they are a potential discharger of urban runoff in the permitted areas. Under the permit, it is expected that SANBAG work cooperatively with the permittees to manage urban runoff. Pursuant to 40 Code of Federal Regulations (CFR) 122.26(a), the Santa Ana RWQCB has the authority to require non-cooperating entities to adhere to the requirements of the NPDES permit or issue individual discharge permits to those entities. Therefore, to comply with this requirement, this PWQMP has been prepared for the proposed project that specifies the BMPs to be implemented during operation.

1.15.4.2. City of San Bernardino General Plan

The City of San Bernardino's General Plan contains several policies regarding water quality in the Utilities Element (Chapter 9, Storm Drains and Flood Control Facilities section) and Energy and Water Conservation Element (Chapter 13). Specifically, it provides a framework and guiding policies to guide future development to comply with water quality regulations within the City. The guiding policies in regards to water quality as they apply to this project are as follows:

1. Policy 9.4.8: Minimize the amount of impervious surfaces in conjunction with new development.
2. Policy 9.4.9: Develop and implement policies for adopting Sustainable Stormwater Management approaches that rely on infiltration of stormwater into soils over detention basins or channels. Sustainable Stormwater Management techniques include

use of pervious pavements, garden roofs, and bioswales to treat stormwater, and reusing stormwater for non-potable water uses such as landscape irrigation and toilet/urinal flushing.

3. Policy 9.4.10: Ensure compliance with the Federal Clean Water Act requirements for National Pollutant Discharge Elimination System (NPDES) permits, including requiring the development of Water Quality Management Plans, Erosion and Sediment Control Plans, and Storm Water Pollution Prevention Plans for all qualifying public and private development and significant redevelopment in the City.
4. Policy 9.4.11: Implement an urban runoff reduction program consistent with regional and federal requirements, which includes requiring and encouraging the following examples of Best Management Practices (BMPs) in all developments:
    a. Increase permeable areas, utilize pervious materials, install filtration controls (including grass lined swales and gravel beds), and divert flow to these permeable areas to allow more percolation of runoff into the ground;
    b. Replanting and hydroseeding of native vegetation to reduce slope erosion, filter runoff, and provide habitat;
    c. Use of porous pavement systems with an underlying stone reservoir in parking areas;
    d. Use natural drainage, detention ponds, or infiltration pits to collect and filter runoff;
    e. Prevent rainfall from entering material and waste storage areas and pollution-laden surfaces; and
    f. Require new development and significant redevelopment to utilize site preparation, grading, and other BMPs that provide erosion and sediment control to prevent construction-related contaminants from leaving the site and polluting waterways.
5. Policy 13.2.7: Require that new development incorporate improvements to channel storm runoff to public storm drainage systems and prevent discharge of pollutants into the groundwater basins and waterways. (LU-1).
6. Policy 13.2.8: Require that Best Management Practices (BMPs) are implemented for each project to control the discharge of point source and non-point source pollutants both during construction

and for the life of the projects to protect the City's water quality. (LU-1).

7. Policy 13.2.9: Require that new construction on a site that is at least one acre comply with the General Permit for Discharges of Storm Water Associated with Construction Activity (Construction General Permit 99-08-DWQ)). (LU-1).

1.15.4.3. City of San Bernardino Municipal Code

Storm water discharge is regulated under Chapter 8.80 – Storm Water Drainage System of the City of San Bernardino Code of Ordinances. Under Chapter 8.80 discharge of nonstormwater is permissible only when connection to the storm drain system is made in accordance with a valid city permit, approved construction plan, or a NPDES permit and/or Notice of Intent (NOI). In addition, projects within the City are required to comply with the requirements of the Construction General Permit and the Municipal NPDES Permit, which includes preparation of a SWPPP and implementation of construction and post-construction BMPs.

1.15.4.4. City of Redlands General Plan

The City of Redlands' General Plan contains several policies regarding water quality in the Health and Safety Element. Specifically, it provides a framework and guiding policies to guide future development to comply with water quality regulations within the City. The guiding policies in regards to water quality are as follows:

1. Policy 8.20a: Work with the local and regional water agencies to improve and enhance groundwater quality in the region. The RWQCB's Water Quality Control Plan: Santa Ana River Basin, 1984, with amendments through 1994, specifies regional water quality objectives and implementation measures.
2. Policy 8.20i: The City will actively protect all water supply sources, to the extent legally possible, from contamination and from a diminution of supply, will undertake all necessary steps to provide a secure supply of high quality water to meet the present and future needs of its citizens.
3. Policy 8.40d: Where feasible given flood control requirements, maintain the natural condition of waterways and flood plains to ensure adequate groundwater recharge and water quality, preservation of habitat, and access to mineral resources.

1.15.4.5. City of Redlands Municipal Code

Storm water discharge is regulated under Chapter 13.54 – Storm Drains of the Redlands Municipal Code (RMC). The majority of this Chapter references Ordinance No. 2274. Ordinance No. 2742, approved by the City Council on November 16, 2010, revised portions of this Chapter as well as Chapter 5.04.

Under Chapter 13.54 discharge of nonstormwater is permissible only when connection to the storm drain system is made in accordance with a valid city permit, approved construction plan, or a NPDES permit and/or NOI. In addition, projects within the City are required to comply with the requirements of the Construction General Permit and the Municipal NPDES Permit, which includes preparation of a SWPPP and implementation of construction and post-construction BMPs, not to mention required reporting, and collection of NPDES Program Regulatory Fees.

2. Pollutants of Concern and Hydrologic Conditions of Concern

2.1. Pollutants of Concern (POCs)

The 2012-2035 RTP/SCS provides a background of pollutant sources from transportation projects and focuses on the nexus of transportation projects and impervious surfaces. Projects that increase impervious surface areas increase urban runoff, resulting in the transport of greater quantities of contaminants to receiving waters that may currently be impaired. Even though this document centers on highway projects, there is similarity of this impact to rail projects although without the extensive impervious areas typically associated with highways. Rail projects are not known for pollutants in urban runoff attributable to landscape irrigation as are the case for highway projects. However, like highway runoff, railroad runoff is a component of urban runoff contributing oil and grease, sediment, nutrients, heavy metals, and toxic substances. Table 2-1 lists the pollutants commonly associated with transportation.

Table 2-1. Pollutants Associated with Transportation

Pollutant	Source
Asbestos	Clutch plates, brake linings
Cadmium	Tire wear(1) and insecticides
Copper	Thrust-bearing, bushing, brake linings, and fungicides and insecticides
Chromium	Pavement materials(2), metal plating, rocker arms, crankshafts, rings, and brake linings
Cyanide	Anti-caking compound in de-icing salt
Lead	Leaded gasoline, motor oil, transmission babbit metal bearings, tire wear(1)
Iron	Auto-body rust(3), steel highway structures, moving engine parts
Manganese	Moving engine parts
Nickel	Diesel fuel and gasoline, pavement material(2), lubricating oil, metal plating, bushing wear, and brake linings
Nitrogen and Phosphorus	Motor oil additives, fertilizers
Sulphates	Roadway beds(1), fuel, and de-icing salt(1)
Zinc	Motor oil and tires(1)
Grease and Hydrocarbons	Spills and leaks of oil and n-parafin lubricants, antifreeze, hydraulic fluids
Rubber	Tire wear(1)
Sediment	Pavement wear(2), construction and maintenance activities

SOURCE: USEPA Office of Water. (1995) *Controlling Nonpoint Source Runoff Pollution from Roads, Highways, and Bridges*. (EPA-841-F-95-008a).
Washington DC

Notes:
(1) Normally associated with highway use and not railroad use.
(2) Normally associated with highway use; may be associated with rail use especially at yards and maintenance facilities, and access/maintenance roads.
(3) The railroad equivalent is train car body rust.

Pollutants of Concern (POCs) will only be identified and addressed for drainage associated with the Project ROW (onsite) in addition to station improvements (i.e., platforms, pedestrian crossovers, walkways, parking lots, etc.). It is assumed the Project ROW is owned by SANBAG or will be owned by SANBAG through acquisition to accommodate proposed improvements. POCs related to tributary offsite drainage areas are not the responsibility of the project and will not be focused in this discussion.

2.1.1. Existing Conditions

Onsite/Corridor

An existing "red board" is located west of Tippecanoe Avenue that prevents any rail traffic further east. No rail activity has occurred east of MP 4.3 or Tippecanoe Avenue since 1938. However, for purposes of this discussion, it will be assumed that rail activity is ongoing for the entire project and are currently generating associated POCs as discussed below.

Under existing conditions pollutants generated by the project site include: heavy metals, organic compounds, sediments, trash and debris, and oil and grease. Table 2-2 below identifies the expected and potential pollutants anticipated to be generated by the development. It is assumed that the pollutants generated by this project are similar to those in the street/highway/freeway project category, as listed in Table 2-2 below (Table 2-1 of the WQMP Guidance).

Table 2-2. Pollutant of Concern Project Category Summary

Pollutant Type	Expected	Potential	Listed for Receiving Water
Bacteria/Virus (3)		X	Santa Ana River, Reach 4
Heavy Metals	X		No
Nutrients (1)		X	No
Pesticides (1)		X	No
Organic Compounds (2)	X		No
Sediments	X		No
Trash & Debris	X		No
Oxygen Demanding Substances (1)		X	No
Oil & Grease	X		No
Other—specify pollutant(s):			N/A

Notes:
(1) A potential pollutant if landscaping or open area is present on site.
(2) Including petroleum hydrocarbons.
(3) Bacterial indicators are routinely detected in pavement runoff.

According to Table 2-2, this project category has the potential to produce the following pollutants of concern: bacteria/virus, nutrients, pesticides, and oxygen demanding substances.

Bacteria and viruses are commonly found in organic materials that are part of stormwater. Principal sources include sanitary sewer overflows and leakages, animal excrement from farms, food particles, water used to prepare or clean food or food packaging, and restaurants. The presence of pathogens can transform an otherwise attractive stream or lake into a public hazard that must be avoided. Animal excrement may also be found along pedestrian walkways or parks when pets are present. However, since such amenities and other described uses above do not exist onsite, the Project is not expected to produce bacteria/virus related pollutants and they are not considered POCs.

Nutrients, pesticides, and oxygen demanding substances are commonly found in landscaped and open areas. Landscaping and open grassed areas do not exist onsite, therefore nutrients and oxygen demanding substances are not considered pollutants of concern. However, herbicides are used by the railroad as part of the ongoing maintenance program to control plant growth and reduce fire risk from overgrowth of vegetation. Consequently, the pesticides category is expected as a POC because it includes pesticides, herbicides, and insecticides.

The use of wood ties which are treated with creosote and other preservatives which can leak into the underlying soil and be mobilized in stormwater runoff to the detriment of water quality. Creosote is obtained from high temperature distillation of coal tar. Historical research has determined that the existing railroad ballast does not include metal slag which has the potential to leak hazardous metals.

Heavy metals, organic compounds, sediments, trash and debris, and oil and grease are all expected POCs associated with this project category. Therefore, a summary of the POC expected from the existing conditions of the site can be found below in Table 2-3.

Table 2-3. Pollutant of Concern Project Category Summary

Pollutant Type	Expected	Listed for Receiving Water
Heavy Metals	X	No
Pesticides	X	No
Organic Compounds	X	No
Sediments	X	No
Trash & Debris	X	No
Oil & Grease	X	No

Comparison of the anticipated pollutants listed in Table 2-3 above and the receiving water bodies' impairments identify no primary pollutants of concern. Therefore all categories listed above in Table 2-3 are considered secondary pollutants of concern.

Within Reach 4 of the SAR, the project is associated with a receiving water body that is listed on the 2006 and the 2010 CWA Section 303(d) list of impaired water bodies. Listed pollutants, for both lists, are pathogens along the SAR. However, there are no listed impaired water bodies on

either list for Reach 5 of the SAR. No TMDLs have been identified for the project. There are no known pre-existing water quality problems at the project site.

Offsite (Properties, Grade Crossings)

As stated above, POCs from tributary offsite areas are the responsibility of other stakeholders within their respective ROW such as private properties, City of Redlands, City of San Bernardino, Caltrans and SBCFCD.

2.1.2. Proposed Conditions

Onsite/Corridor

Under proposed conditions, pollutants generated by the project site will be the same as those identified for existing conditions. Refer to the Existing Conditions section for expected and potential pollutants and Table 2-2.

Amenities such as platforms, pedestrian crossovers, and walkways in proposed stations will be expected to produce bacteria/virus related pollutants and they are considered POCs. Such amenities invite pets that are the source of such pollutants, and paved areas are also documented to be such sources as well. Impervious areas are also proposed along concrete-lined ditches and the layover facility. The layover facility will include impervious areas for related parking areas and maintenance access roads.

Nutrients, pesticides, and oxygen demanding substances are commonly found in landscaped and open areas. Landscaping and open grassed areas are proposed as part of the Project station improvements, therefore nutrients and oxygen demanding substances not considered pollutants of concern. Herbicides will continue to be used by the railroad as part of the ongoing maintenance program to control plant growth and reduce fire risk from overgrowth of vegetation. Consequently, the pesticides category is expected as a POC because it includes pesticides, herbicides, and insecticides.

Heavy metals, organic compounds, sediments, trash and debris, and oil and grease are assumed to continue to be expected pollutants of concern associated with this project category.
Concrete ties are proposed to replace the wood ties (and at greater separation spacings than wood ties) which will have a water quality benefit; hence, there will be more wood ties removed than replaced with concrete ties.

The Project will not increase the concentrations of pollutants beyond their current concentrations because the onsite land use is not changing. In fact, potential of pollutants in runoff will most likely be reduced since all the wood ties will be removed. Therefore, a summary of the pollutants of concern expected from the re-development associated with this project can be found in Table 2-3.

In order to prevent degradation of receiving water quality, Source Control, Site Design, and Treatment Control BMPs will be implemented to target constituents of concern in runoff from the project area.

Offsite (Properties, Grade Crossings)

As stated above, POCs from tributary offsite areas are the responsibility of other stakeholders within their respective ROW such as private properties, City of Redlands, City of San Bernardino, Caltrans and SBCFCD. These POCs and their impacts will not be identified or addressed.

The extent of the offsite amenities such as parking lots (associated with proposed stations) and how they are associated with the Project are yet to be defined in forthcoming Memoranda of Understanding. Once these agreements are defined, the POCs from associated improvements will be identified and be mitigated as part of the PS&E phase. These POCs and their impacts will not be identified or addressed

2.2. Hydrologic Conditions of Concern

Table 2-3 below is used to identify any hydrologic conditions of concern (HCOC) that will be caused by the project. Once identified, site design, source control, and/or treatment control BMPs will be implemented to address identified impacts.

Table 2-3. Hydrologic Condition of Concern

1. Determine if the project will create a Hydrologic Condition of Concern. Check "yes" or "no" as applicable and proceed to the appropriate section as outlined below.	**Yes**	**No**
A. All downstream conveyance channels, that will receive runoff from the project, are engineered, hardened (concrete, riprap or other), and regularly maintained to ensure design flow capacity, and no sensitive stream habitat areas will be affected. Engineered, hardened, and maintained channels include channel reaches that have been fully and properly approved (including CEQA review, and permitting by USACOE, RWQCB and California Dept. of Fish & Game) by June 1, 2004 for construction and hardening to achieve design capacity, whether construction of the channels is complete. Discharge from the project will be in full compliance with Agency requirements for connections and discharges to the MS4, including both quality and quantity requirements, and the project will be permitted by the Agency for the connection or discharge to the MS4.		**X**
B. Project runoff rates, volumes, velocities, and flow duration for the post-development condition will not exceed those of the pre-development condition for 1-year, 2-year and 5-year frequency storm events. This condition will be substantiated with hydrologic modeling methods that are acceptable to the Agency, to the U.S. Army Corps of Engineers (USACOE), and to local watershed authorities. See supporting documentation below.	**X**	

C.	Can the conditions in part A or B above be demonstrated for the project?	**X**	
▪ If the answer for A, B, and/or C above is yes, then the project does not create a HCOC. ▪ If the answer for C above is no, then the project does create a HCOC, and an evaluation must be performed.			

The project proposes to mitigate the increase in the post-development runoff rates, volumes, velocities, and flow durations to meet the condition specified above; therefore according Section B of the above table, this project will not create a HCOC. Even though the impervious area is being increased, the computations to justify this will be provided in the WQMP during PS&E phase when the design is further refined. See Section 2.2.3 for more information.

2.2.1. Design Methodology

During PS&E, the project will utilize Rational Method software, developed by AES software to calculate the unit hydrographs for the impervious areas that have an HCOC impact. The AES software is an approved software by the SBCFCD and is in accordance with the San Bernardino County Hydrology Manual.

2.2.2. Existing Conditions

There are no existing HCOCs for the project.

2.2.3. Proposed Conditions

Analysis

The Project will include features to address stormwater quantity and quality. Approximately 21 acres of impervious area will be created, mostly at the stations, parking lots and layover facility, and will be associated with an increase in runoff rates, volumes, velocities, and flow duration and therefore require additional mitigation. Per Order No. R8-2010-0036 the 2-year frequency will have to be analyzed during PS&E using the Unit Hydrograph Method.

For each return frequency under the pre- and post-development conditions the total runoff volume, the peak flow rate, and the time of duration, of runoff hydrograph flow rates that exceed the flow rate in 10 percent increments from 90 percent to 10 percent (90 percent of peak flow rate to 10 percent peak flow rate) will be computed. The values will be populated below in Table 2-4 for each of the stations. Refer to Appendix A, Project Exhibits for additional information and Preliminary H&H Study for existing and proposed hydrology calculations.

Table 2-4. Pre- and Post-development Hydrology Comparison Worksheet

(To be filled in during PS&E phase)

Return Period	Total Volume		Peak Flow		Flow Time Duration			Sediment Transport [1]	
	Pre	Post	Pre	Post	% of Peak	Pre	Post	Pre	Post
1-year	___ Ac-Ft	___ Ac-Ft	___ CFS	__ CFS		5 min	0 min	-	-
						10 min	0 min	-	-
						20 min	0 min	-	-
						20 min	0 min	-	-
						25 min	0 min	-	-
						30 min	0 min	-	-
						30 min	0 min	-	-
						45 min	0 min	-	-
						85 min	0 min	-	-
2-year	___ Ac-Ft	0 Ac-Ft	___ CFS	0 CFS		5 min	0 min	-	-
						10 min	0 min	-	-
						20 min	0 min	-	-
						20 min	0 min	-	-
						25 min	0 min	-	-
						30 min	0 min	-	-
						45 min	0 min	-	-
						55 min	0 min	-	-
						115 min	0 min	-	-
5-year	___ Ac-Ft	0 Ac-Ft	___ CFS	0 CFS		5 min	0 min	-	-
						10 min	0 min	-	-
						20 min	0 min	-	-
						20 min	0 min	-	-
						30 min	0 min	-	-
						30 min	0 min	-	-
						45 min	0 min	-	-
						60 min	0 min	-	-
						145 min	0 min	-	-

Notes:
(1) Sediment Transport not applicable. See justification below.

Sediment risk analysis was evaluated in the Risk Determination Analysis for the construction phase using the RUSLE to obtain an estimate of project-related bare ground soil loss expressed in tons/acre. Sediment transport does not apply to this analysis because sediment discharge during operation is not expected by the project.

Results

The proposed project increases the impervious cover onsite, and therefore creates an increase in stormwater runoff and volume. The Project will mitigate this increase in runoff through the implementation of various BMPs, such as, but not limited to, vegetated swales, small infiltration basins, permeable surfaces, to be determined during the PS&E phase. The will be designed to retain and infiltrate the 100-year storm, returning the overall discharge from the site to existing conditions. Refer to the Preliminary H&H Study for a detailed description of the analysis for the 100-year design. Section 2.3 of the WQMP Guidance only requires that the 1-, 2-, and 5-year storm be analyzed for water quality management. Refer to the Preliminary H&H Study for a summary of the flows from the proposed onsite watershed complying with the aforementioned requirements.

During PS&E, the Project will demonstrate that the proposed conditions discharges and volumes for the analyzed watershed, which accounts for the proposed features described above in Section 2.1.2 will be less than the existing conditions discharges. As such, the project will not create a HCOC.

2.3. Watershed Impacts of Project

According to Section 2.1, there are six categories of pollutants of concern which can be expected from the re-development of the project site: heavy metals, pesticides including herbicides and insecticides, organic compounds, sediments, trash and debris, and oil and grease. The SAR is the receiving water for the project site, and none of the aforementioned pollutants are listed as POCs for this water body; therefore these pollutants are all considered secondary pollutants of concern. Treatment of these pollutants will be discussed in Section 3.3 below.

According to Section 2.1.2, the proposed project will create an increase in runoff. A discussion of the design for these BMPs, and for all treatment BMPs can be found below in Section 3.3. The project is required to implement all BMPs as described in Sections 3.1, 3.2, and 3.3 below; these BMPs will further refined during PS&E. As such it has been determined that the project will not cause any significant impact(s) to any downstream receiving waters.

2.4. Future Conditions (Watershed Action Plan)

As required by the current San Bernardino County Municipal Separate Storm Sewer System (MS4) permit, San Bernardino County and the permittees (including City of San Bernardino and Redlands) are required to develop a Watershed Action Plan (WAP) in two phases, one of many

mandated document required to be in compliance with the permit. The WAP Phase 1 was developed through a collaborative process with the County, the co-permittees, and other watershed stakeholders. The WAP development involved several WAP Task Force meetings and WAP development workshops where watershed stakeholders provided input on the WAP and watershed development processes. The County and co-permittees intend to use the WAP to help improve water quality and to implement an integrated water resources approach in the Santa Ana River Watershed.

The WAP is structured to help the County, co-permittees, and stakeholders collaborate with Orange and Riverside Counties to ensure a holistic approach to watershed management throughout the SAR Watershed. Its purpose is to improve integration of water quality, stream protection, stormwater management, water conservation and re-use, and flood protection with land use planning and development processes. This goal will be accomplished using:

- An Integrated Watershed Management Approach, an imperative methodology that should be used whenever planning a sustainable development or community intended to coexist with and compliment the native environment and ecosystem in which it resides in.
- Watershed protection principles and policies necessary for water quality protection, including avoiding disturbance of water bodies, minimizing changes in hydrology and pollutant loading, preserving wetlands and other natural areas, using appropriate Best Management Practices, employing the Ahwahnee Principles of community design, using CEQA and Low Impact Development, and others.

The Hydromodification Plan (Appendix B, Hydromodification Assessment Technical Memorandum) of the WAP Phase 1 identified those stream reaches that are subject to adverse impacts from hydromodificatin and identified the drainage areas tributary to those streams that are determined to be at risk. All Major Flood Control Facilities crossed by the project are identified as Engineered, Hardened and Maintained (EHM) channels (armored drainage conveyances that are not vulnerable to geomorphological changes and hydromodification). The only exception is (1) Mission Zanja Channel which is categorized as a non-EHM facility and has an associated high hydromodification classification from SAR to Gage Canal (MP 3.4/3.9), and (2) Mill Creek Zanja which is categorized as a non-EHM facility and has an associated medium hydromodification classification from Division Street to Cook Street. Offsite areas tributary to Warm Creek (Historic) and Mission Zanja Channel are identified on the plan as subject to hydromodification. Specifically, for Warm Creek (Historic), the extent of the hydromodification area spans from E Street to Arrowhead Avenue. For Mission Zanja Channel, the hydromodification area spans throughout the associated Project extents, except the portion from the SAR to Mountain View Avenue the area only applies along the south side of the Channel; from Mountain View Avenue east the area applies to both sides (north and south) of the Channel.

Phase 1 of the WAP was submitted and approved by the Santa Ana RWQCB on July 6, 2011. WAP Phase 2 is currently under preparation and slated for submittal to the Santa Ana RWQCB by early 2013. WAP Phase 2 will include development and implementation of a Hydromodification Management Plan that is prioritized based on drainage feature/susceptibility/risk assessments and opportunities for restoration. Additionally, by January 29, 2013, each co-permittee shall review the watershed protection principles and policies in its General Plan or related documents (such as Development Standards, Zoning Codes, Conditions of Approval, Development Project Guidance) to determine consistency with the WAP.

3. Best Management Practice Selection Process

3.1. Site Design BMPs

Table 3-1 below identifies information on proposed site design BMPs used and associated descriptions and justifications. These BMPs will be further refined during PS&E. Refer to Appendix A for Project Exhibits and Appendix C, CASQA BMP Fact Sheets, for more information on proposed BMPs.

Table 3-1. Site Design BMPs

1. Minimize Stormwater Runoff, Minimize Project's Impervious Footprint, and Conserve Natural Areas		
A. Maximize the permeable area. This can be achieved in various ways, including but not limited to, increasing building density (number of stories above or below ground) and developing land use regulations seeking to limit impervious surfaces.		
Yes	No X	
Describe actions taken or justification/alternative: *The existing condition for the project area consists of the mainline tracks, and surrounding pervious areas which are mostly covered with gravel or bare earth. The proposed project will include the improvement of rail tracks, the addition of five stations, parking lots, layover facility, and site drainage features as described in Section 1.6 above. The proposed track section is considered as permeable as the existing track section. Stormwater filtered through the ballast contacts the impervious sub-ballast layer and drains to the left/right until it continues percolating into the underlying soil. Proposed maintenance roads at the layover facility may be gravel/ballast and are considered to be pervious, but this will not be decided until PS&E. All replaced wood ties will be replaced with concrete ties (but at a lower replacement ratio since the spacing between concrete ties is greater than that for wood ties) but given that wood ties are considered as impermeable as concrete ties, there is no increase in the impermeable areas from the track sections. Hence, the tracks and other site features will be considered pervious.* *During PS&E, consideration will be given to reducing the impervious area at the proposed platforms/station and parking areas. Likewise, for the proposed layover facility.*		
B. Runoff from developed areas may be reduced by using alternative materials or surfaces with a lower Coefficient of Runoff, or "C-Factor".		
Yes	No X	
Describe actions taken or justification/alternative: *For the tracks, there are no alternative materials or surface types which would satisfy the design requirements. These portions of the project will be assumed to be as pervious as the existing tracks; hence, there will not be a change to the C-factor. There are no alternative materials to create the base of this structure which would satisfy the design requirements. The maintenance roads will be gravel/ballast, considered pervious, and have a lower C-factor than other traditional materials like asphalt.* *During PS&E, consideration will be given to using materials that have a lower C-factor in the stations/platforms and layover facility such as permeable pavements.*		

C. Conserve natural areas. This can be achieved by concentrating or clustering development on the least environmentally sensitive portions of a site while leaving the remaining land in a natural, undisturbed condition.		
Yes	No X	
Describe actions taken or justification/alternative: *The project is not conducive to concentrating or clustering development as the project alignment is along the existing SANBAG rail alignment which is already disturbed and absent of most vegetation. The area proximate to proposed stations/platforms will conserve natural areas as feasible. Any environmentally sensitive areas (ESA) which are disturbed in the existing condition will remain disturbed.* *There may opportunities to conserve natural area at the proposed stations/platforms especially at the New York station. This will be further refined during PS&E phase.*		
D. Construct walkways, trails, patios, overflow parking lots, alleys, driveways, low-traffic streets, and other low-traffic areas with open-jointed paving materials or permeable surfaces, such as pervious concrete, porous asphalt, unit pavers, and granular materials.		
Yes	No X	
Describe actions taken or justification/alternative: *The rail corridor is not conducive to these types of improvements and these BMPs are not included as part of the rail corridor. However, the proposed platforms will include sidewalks, parking lots and other paved surfaces that are good opportunities for permeable surfaces. The feasibility to incorporate these elements will be further investigated during the PS&E phase.*		
E. Construct streets, sidewalks, and parking lot aisles to the minimum widths necessary, provided that public safety and a pedestrian friendly environment are not compromised [(1)]. Incorporate landscaped buffer areas between sidewalks and streets.		
Yes	No X	
Describe actions taken or justification/alternative: *Sidewalks will be constructed as part of the platforms and at certain grade crossing locations as identified in Item D above. Any parking lots will be designed to local standards. There will be opportunities at the stations to include landscaped buffer areas and will be determined during the PS&E phase.*		
F. Reduce widths of street where off-street parking is available [(2)].		
Yes	No X	
Describe actions taken or justification/alternative: *This practice does not apply to the project since the project will not include street improvements other than grade crossing improvements. At various grading crossings, curb medians will be constructed for public safety and to reduce the traveled way in each direction, but the outside curb-to-curb distance will remain the same. Due to SANBAG standards, off-street parking is not permitted near grade crossings.*		

G. Maximize canopy interception and water conservation by preserving existing native trees and shrubs, and planting additional native or drought tolerant trees and large shrubs.		
Yes	No X	
Describe actions taken or justification/alternative: *The majority of the project disturbance will be in areas that are covered by tracks, ballast, or bare earth in the existing condition. Existing canopy interception and preservation of existing landscaping do not apply to these areas. There are small portions of the work which may involve disturbance of the slopes along both I-10 overpasses and associated on-ramps. Some of these areas are covered with grass and sparse shrubs in the existing conditions, and will be restored in accordance with project specifications and the project SWPPP.* *There may be opportunities in the proposed stations/platform to maximize canopy interception.*		
H. Other comparable site design options that are equally effective.		
Describe actions taken or justification/alternative: *Other than site design options that may be incorporated into the stations and parking lots, no other site design BMPs are viable to incorporate into the project.*		
I. Minimize the use of impervious surfaces, such as decorative concrete, in the landscape design.		
Yes	No X	
Describe actions taken or justification/alternative: *The railroad corridor will not incorporate these features as they are not feasible and not consistent with SCRRA and SANBAG standards. However, the proposed stations have the opportunity to incorporate these features in coordination with the proposed landscaping improvements. Likewise, there may be an opportunity to use these features in the maintenance roads and parking lots at the layover facility.*		
J. Use natural drainage systems.		
Yes	No X	
Describe actions taken or justification/alternative: *There are no onsite natural drainage systems that may be used. However, several natural drainage systems convey offsite flows and intersect the project such as the SAR, Warm Creek (Historic), Twin Creek, Mission Zanja Channel, and Mill Creek Zanja and are identified as jurisdictional delineated (JD) features. Tributary onsite drainage will be treated onsite before it discharges via ditches, local culverts and City master drainage facilities to these features. All features ultimately outlet to the SAR. After construction, the JD features will continue being JD features.*		
K. Where soils conditions are suitable, use perforated pipe or gravel filtration pits for low flow infiltration [(3)].		
Yes	No X	
Describe actions taken or justification/alternative: *For the tracks, perforated underdrain pipe systems will be used for drainage of the track ballast. Runoff from the rail tracks will drain to the adjoining graded ditches (no cover) and will infiltrate directly into the underlying native soils. This design will provide the same level of infiltration and treatment as perforated pipes or gravel*		

filtration pits. For the proposed stations, perforated pipes or gravel filtration pits will not be used. There will be opportunities to use other infiltration-type BMPs to be consistent with LID. The specific BMPs to be used will be determined during the PS&E phase.

L. Construct onsite ponding areas, rain gardens, or retention facilities to increase opportunities for infiltration, while being cognizant of the need to prevent the development of vector breeding areas.

Yes X	No	

Describe actions taken or justification/alternative:

The only elements of the project that may incorporate these features are the proposed stations. Every opportunity will be provided to incorporate these BMPs into the stations and parking lots. Any proposed impoundments will have a maximum drawdown time of 48 hours to be consistent with State Public Health requirements and CASQA Stormwater BMP Handbooks. See Sections 3.3 and 4 for discussions of the design and maintenance of these facilities, respectively.

2. Minimize Directly Connected Impervious Areas

A. Where landscaping is proposed, drain rooftops into adjacent landscaping prior to discharging to the storm drain.

Yes	No X	

Describe actions taken or justification/alternative:

There are portions of the rail corridor adjacent to buildings that will accept historical runoff from roof drains. But the roof drain runoff will discharge to the proposed side ditches without causing impacts to the building/property owners. This runoff will be treated by the ditches before it discharges to any associated public storm drain systems. The only elements of the project that may incorporate landscaping are the proposed stations and parking lots. However, the stations do not include buildings that would rely on roof drains.

B. Where landscaping is proposed, drain impervious sidewalks, walkways, trails, and patios into adjacent landscaping.

Yes	No X	

Describe actions taken or justification/alternative:

The only elements of the project that may incorporate these features are the proposed stations. Every opportunity will be leveraged to slope proposed impervious surfaces into adjacent proposed landscaping improvements, if applicable.

C. Increase the use of vegetated drainage swales in lieu of underground piping or imperviously lined swales.

Yes	No X	

Describe actions taken or justification/alternative:

The proposed design incorporates pervious drainage swales (ditches) along the edges of the tracks where feasible (i.e., ROW is available). SANBAG requirements do not allow vegetated cover drainage side ditches in order to reduce fire risks; therefore these ditches will consist of compacted native soil (soft). However, it is expected that infiltration along the underlying soil and soft drainage swales will provide some level of treatment of runoff.

Every opportunity will be leveraged to use vegetated drainage swales in the proposed stations. This will be coordinated with the proposed landscaping and irrigation improvements during PS&E phase.

D. Use one or more of the following:

Yes	No	Design Feature
	X	Rural swale system: street sheet flows to vegetated swale or gravel shoulder, curbs at street corners, culverts under driveways and street crossings
	X	Urban curb/swale system; street slopes to curb; periodic swale inlets drain to vegetated swale/biofilter.
	X	Dual drainage system: First flush captured in street catch basins and discharged to adjacent vegetated swale or gravel shoulder, high flows connect directly to municipal storm drain systems.
	X	Other comparable design concepts that are equally effective.

Describe actions taken or justification/alternative:

The requirements of this project are such that the rail portion does not apply to reduction of directly connected impervious areas. The nature of the rail portion is such that impervious areas do not exist nor are they proposed. The only opportunity to include any of the above mentioned design features are at the proposed stations and parking lots. This will be evaluated for the proposed stations during PS&E phase.

E. Use one or more of the following features for design of driveways and private residential parking areas:

Yes	No	Design Feature
	X	Design driveways with shared access, flared (single lane at street) or wheel strips (paving only under tires); or, drain into landscaping prior to discharging to the municipal storm drain system.
	X	Uncovered temporary or guest parking on private residential lots may be paved with a permeable surface; or designed to drain into landscaping prior to discharging to the municipal storm drain system.
	X	Other comparable design concepts that are equally effective.

Describe actions taken or justification/alternative:

This practice does not apply to the rail portion of the project. However, there may be an opportunity to leverage the design of the proposed stations and parking lots to incorporate these features. This will be evaluated for the proposed stations and parking lots during PS&E phase. The project does not include residential parking areas.

F. Use one or more of the following design concepts for the design of parking areas:

Yes	No	Design Feature
X		Where landscaping is proposed in parking areas, incorporate landscape areas into the drainage design.
X		Overflow parking (parking stalls provided in excess of the Agency's minimum parking requirements) may be constructed with permeable paving.

X		Other comparable design concepts that are equally effective.
Describe actions taken or justification/alternative: *This practice only applies to the proposed stations and parking lots. Every opportunity will be leveraged to include these design features in the proposed station improvements during PS&E phase.*		

Notes:
(1) Sidewalk widths must still comply with Americans with Disabilities Act regulations and other life safety requirements.
(2) However, street widths must still comply with life safety requirements for fire and emergency vehicle access.
(3) However, projects must still comply with hillside grading ordinances that limit or restrict infiltration of runoff. Infiltration areas may be subject to regulation as Class V injection wells and may require a report to the USEPA. Consult the Agency for more information on use of this type of facility.

3.2. Source Control BMPs

This section will serve as a guide to implementation of planned Source Control BMPs proposed for the project. BMPs selected in Table 3-2 below will be implemented for the project, and all BMPs will be justified for their use or non applicability in Table 3-3 below. Refer to Appendix A for Project Exhibits and Appendix C, CASQA BMP Fact Sheets, for more information on proposed BMPs.

Table 3-2. Source Control BMP Selection Matrix

Source Control BMPs	Significant Re-development
Education of Property Owners	X
Activity Restrictions	X
Spill Contingency Plan	X
Employee Training/Education Program	X
Street Sweeping Private Street and Parking Lots	X
Common Areas Catch Basin Inspection	X
Landscape Planning (SD-10)	X
Hillside Landscaping	
Roof Runoff Controls (SD-11)	
Efficient Irrigation (SD-12)	X
Protect Slopes and Channels	X
Storm Drain Signage (SD-13)	X
Inlet Trash Racks	
Energy Dissipaters	X
Trash Storage Areas (SD-32) and Litter Control	X
Fueling Areas (SD-30)	X

Air/Water Supply Area Drainage	
Maintenance Bays and Docks (SD-31)	X
Vehicle Washing Areas (SD-33)	X
Outdoor Material Storage Areas (SD-34)	X
Outdoor Work Areas (SD-35)	X
Outdoor Processing Areas (SD-36)	X
Wash Water Controls for Food Preparation Areas	
Pervious Pavement (SD-20)	X
Alternative Building Materials (SD-21)	X

Table 3-3. Justification for Source Control BMPs

Source Control BMP	Used in Project (yes/no)?	Justification/Alternative	Implementation Description
A. Education of Property Owner	Yes	There is no Property Owners Association for this project, as the property is owned by SANBAG.	SANBAG will be provided with the Stormwater Pollution Prevention Best Management Practices for Homeowner's Associations, Property Managers and Property Owners Manual. Refer to Appendix D for a copy of this manual.
B. Activity Restrictions	Yes	Certain activities are restricted to comply with OSHA under 29 C.F.R. 1910.120(q) and also with the Industrial General Permit. Information is to be provided to personnel who may become involved in a hazardous materials incident.	Pesticide applications along the bare soil sections will be performed by an applicator certified by the California Department of Pesticide Regulation. Also, SANBAG will implement SANBAG Hazardous Material Emergency Response Plan (insert date when available).Also all activities will be done in accordance with the Industrial SWPPP.
C. Spill Contingency Plan	Yes	Certain activities are restricted to comply with OSHA under 29 C.F.R. 1910.120(q). Information is to be provided to personnel who may become involved in a hazardous materials incident.	SANBAG will implement SANBAG Hazardous Material Emergency Response Plan (insert date when available) and will coordinate with the Industrial SWPPP.
D. Employee Training / Education Program	Yes	Refer to Item A, B, and C of this table.	Refer to Item A, B, and C of this table.

E. Street Sweeping Private Street and Parking Lots	Yes	Street sweeping of private streets does not apply. Also street sweeping of grade crossings does not apply as this is the jurisdiction of the local respective City. However, sweeping of stations/parking lots would be the responsibility of SANBAG.	See Section 4 for stormwater BMP maintenance requirements.
F. Common Areas Catch Basin Inspection	Yes	All drainage facilities including inlets and catch basins within railroad ROW will be inspected and maintained by SANBAG.	See Section 4 for stormwater BMP maintenance requirements.
G. Landscape Planning (SD-10)	Yes	The project will include landscape planning in the proposed station and parking lot design.	The approach to landscaping will be reflected in the PS&E phase. Associated maintenance procedures will be documented.
H. Hillside Landscaping	No	Practice does not apply to project as project does not contain post-construction hillside landscaping.	Not applicable
I. Roof Runoff Controls (SD-11)	No	Practice does not apply to project as project does not contain residential or commercial roof runoff controls. However, the project will coordinate offsite tributary drainage from these adjacent sources.	Not applicable
J. Efficient Irrigation (SD-12)	Yes	The project will include irrigation to support landscape planning in the proposed station designs. This practice will be coordinated with Item G above.	The approach to irrigation will be reflected in the final station designs, and associated operation and maintenance procedures will be documented.
K. Protect Slopes and Channels	Yes	All slopes along proposed tracks, embankments, and access roads and channel slopes will be graded at a maximum of 2:1 or per SANBAG requirements.	All proposed runoff along these slopes will sheet flow, and will not be concentrated to form rills or gullies. The north bank of the Mission Zanja Channel will be armored to protect the respective project limits.

L. Storm Drain Signage (SD-13)	Yes	Project will include signage which instructs that no dumping be permitted in the storm drain inlets, catch basins, side ditches or other BMP features, and for pedestrians to avoid Mission Zanja Channel.	The project will include concrete, non-toxic paint stamping, or equivalent, of all storm water conveyance system inlets and catch basins within the project area with prohibitive language (e.g., "No Dumping – I Live in Santa Ana River"), satisfactory to SANBAG. The project will also include signs and prohibitive language and/or graphical icons, which prohibit illegal dumping at public access points at the stations. Refer to CASQA New Development & Redevelopment BMP Handbook, Source Control BMP Fact Sheet SD-13, Storm Drain Signage.
M. Inlet Trash Racks	No	Practice does not apply to project as project does not contain drainage features which require trash racks.	Not applicable
N. Energy Dissipaters	Yes	Project will include energy dissipaters at the entrance of all piping to applicable culverts, especially those that outlet to Mission Zanja Channel.	Refer to the drainage-related improvement plans during the PS&E phase which will show this information. Riprap will be installed at the inlet/outlet of all storm drain piping to/from culverts to prevent erosion.
O. Trash Storage Areas (SD-32) and Litter Control	Yes	The project will be expected to generate trash and litter by pedestrians at the proposed stations. The layover facility will also generate trash and litter as part of its operations.	During PS&E phase, SANBAG will include trash receptacles in the final design plans at the proposed stations and layover facility. Trash receptacles will be covered and comply with local requirements. This item will be coordinated with the Industrial SWPPP.
P. Fueling Areas (SD-30)	Yes	Fueling will be required at the layover facility.	During PS&E phase, SANBAG will include fueling areas at the layover facility in the final design plans. This item will be coordinated with the Industrial SWPPP.
Q. Air/Water Supply Area Drainage	No	Practice does not apply to project as project does not contain air/water supply drainage areas.	Not applicable

R. Maintenance Bays and Docks (SD-31)	Yes	Maintenance areas will be required at the layover facility.	During PS&E phase, SANBAG will include maintenance areas at the layover facility in the final design plans. This item will be coordinated with the Industrial SWPPP.
S. Vehicle Washing Areas (SD-33)	Yes	Vehicle washing areas will be required at the layover facility.	During PS&E phase, SANBAG will include vehicle washing areas at the layover facility in the final design plans. This item will be coordinated with the Industrial SWPPP.
T. Outdoor Material Storage Areas (SD-34)	Yes	Outdoor material storage areas will be required at the layover facility.	During PS&E phase, SANBAG will include outdoor material storage areas at the layover facility in the final design plans. This item will be coordinated with the Industrial SWPPP.
U. Outdoor Work Areas (SD-35)	Yes	Outdoor work areas will be required at the layover facility.	During PS&E phase, SANBAG will include outdoor work areas at the layover facility in the final design plans. This item will be coordinated with the Industrial SWPPP.
V. Outdoor Processing Areas (SD-36)	Yes	Outdoor processing areas will be required at the layover facility.	Not applicable. This item will be coordinated with the Industrial SWPPP.
W. Wash Water Controls for Food Preparation Areas	No	Practice does not apply to project as project does not contain food preparation areas.	Not applicable
X. Pervious Pavement (SD-20)	Yes	This Practice may have benefit to decrease runoff peak flow, volume and provide required treatment at the proposed stations, thereby minimizing applicable capital cost and O&M responsibilities.	This application will be further evaluated during final design to determine its feasibility.

Y. Alternative Building Materials (SD-21)	Yes	Project will include concrete ties as an alternative to wood ties for the design of the proposed tracks.	Although concrete ties are equally as impermeable as wood ties and do not provide any aid in the reduction of stormwater runoff, they do provide benefit to the project regarding source control for water quality. Wood ties are treated with creosote and other preservatives which can infiltrate into the underlying soil and be mobilized in stormwater runoff. The USEPA released the preliminary risk assessment for creosote, which consisted of a description of creosote and its regulatory history, as well as preliminary human health and ecological risk estimates associated with its use. Therefore, the USEPA suggests the use of plastic and cement railroad ties in place of these wood ties because they do not contain potentially harmful chemicals and are not known to leach any pollutants of concern into stormwater runoff. (Environmental Protection Agency, 2007)

3.3. Treatment Control BMPs

Selection of treatment control BMPs are influenced by primary pollutants of concern, removal efficiencies, expected flows, and applicability to site design constraints. As stated in Section 2.1, there are six categories of pollutants of concern which can be expected from the re-development, however, all are considered secondary as they are not listed for the SAR. Treatment control BMP selection criteria from the WQMP Guidance were used for the selection of treatment BMPs. Table 3-4 below lists the secondary pollutants of concern produced by the project and the relative effectiveness of treatment facilities as provided in Table 2-5 of the WQMP Guidance. See Appendix E for related water quality calculations.

Table 3-4. Treatment Control BMP Selection Matrix

Pollutant of Concern		Treatment Control BMP Categories							
		Biofilters	**Detention Basins**	**Infiltration Basins**	**Wet Ponds or Wetlands**	**Filtration**	**Water Quality Inlets**	**Hydrodynamic Separator Systems**	**Manufactured/ Proprietary Devices**
Sediment/Turbidity		H/M	M	H/M	H/M	H/M	L	H/M (L for turbidity)	U
Yes/No?	Yes			X					
Nutrients		L	M	H/M	H/M	L/M	L	L	U
Yes/No?	Yes			X					
Organic Compounds		U	U	U	U	H/M	L	L	U
Yes/No?	Yes			X					
Trash & Debris		L	M	U	U	H/M	M	H/M	U
Yes/No?	Yes			X					
Oxygen Demanding Substances		L	M	H/M	H/M	H/M	L	L	U
Yes/No?	No								
Bacteria & Viruses		U	U	H/M	U	H/M	L	L	U
Yes/No?	No								
Oils & Grease		H/M	M	U	U	H/M	M	L/M	U
Yes/No?	Yes			X					
Pesticides (non-soil bound)		U	U	U	U	U	L	L	U
Yes/No?	Yes			X					
Metals		H/M	M	H	H	H	L	L	U
Yes/No?	Yes			X					

Notes:

(1) H/M: High or medium removal efficiency;
L: Low removal efficiency;
U: Unknown removal efficiency

(2) Sources: Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (1993), National Stormwater Best Management Practices Database (2001), and Guide for BMP Selection in Urban Developed Areas (2001), California Stormwater BMP Handbook—New Development and Redevelopment (2003).

Secondary pollutants of concern for the project are: heavy metals, pesticides including herbicides and insecticides, organic compounds, sediments, trash and debris, and oil and grease. Treatment control BMPs that most effectively remove these pollutants from stormwater runoff include: detention basins, infiltration basins, wet ponds or wetlands, and filtration. As these are not primary pollutants of concern, it is not mandatory that the chosen BMP have high or medium removal efficiency for every category.

During this preliminary engineering phase, the project does not have sufficient detailed information to design required BMPs. Forthcoming results from the geotechnical investigation will be used to design BMPs during the PS&E phase. The use of site design and source control BMPs described in Sections 3.1 and 3.2, respectively, in conjunction with the treatment BMPs, will also ensure that there is no risk of groundwater contamination.

Based on the location of the project site, drainage patterns, site constraints, treatment efficiencies, maintenance concerns, and the factors listed above, the BMPs to be chosen during final design will be focused on LID and have a preference towards infiltration.

3.4. BMP Design Criteria

Table 3-5 below identifies the types of treatment control BMPs to be considered for implementation to the Project during PS&E phase.

Table 3-5. Design Basis of Treatment Control BMPs

Implemented	Treatment Control BMP	Design Basis
X	Vegetated Buffer Strips	Flow-Based
X	Vegetated Swale	
	Multiple Systems	
	Manufactured/Proprietary	
X	Bioretention	Volume-Based
	Wet Pond	
	Constructed Wetland	
X	Extended Detention Basin	
X	Water Quality Inlet	
	Retention/Irrigation	
X	Infiltration Basins	
X	Infiltration Trench	
	Media Filter	
	Manufactured/Proprietary	

3.4.1. Volume-Based Design Criteria

As described in Section 1.1, 21 acres of impervious acres will be the basis for determining the water quality volume to be treated. Per the preliminary calculations in Appendix E, the required treatment volume will be 2.1 acre-feet. The water quality volumes were calculated in accordance with Attachment D, Section B, of the WQMP Guidance. This required volume may be reduced if the related BMPs are combined with flow-based BMPs.

3.4.2. Flow-Based Design Criteria

Flow-based BMPs will be determined during the PS&E phase. Specific hydrology calculations for 2-year storm events will be performed for each BMP subarea.

4. Operation and Maintenance (O&M)

Operation and maintenance (O&M) will be required for all Source Control, Site Design, and Treatment Control BMPs identified within the PWQMP. Procedures for operating and maintaining each potential BMP will be provided in the WQMP during the PS&E phase. See Appendix C, CASQA BMP Fact Sheets. Refer to Exhibit 3 of Appendix A additional information.

4.1. Inspection & Monitoring Requirements

SANBAG will be responsible for and provide self inspections and record keeping of BMPs at the frequencies identified in the WQMP (PS&E phase) for as long as SANBAG owns the Project.

4.2. Identification of Responsible Parties

The Project owner, SANBAG, will be responsible for the operation and maintenance of all Project-related BMPs identified in the WQMP (PS&E phase) as necessary into perpetuity. SANBAG is aware that periodic and continuous maintenance is required to assure peak performance of all BMPs in the WQMP and that such maintenance activity will require compliance with all local, state, or federal laws. SANBAG will provide access to City representative(s) for inspection, sampling, and testing, as required, of the BMPs on an agreed upon basis by all affected parties. More detailed information on the responsibilities of liable stakeholders and pertinent operation and maintenance agreements among the parties will be provided in the WQMP which will be prepared during the final design phase.

5. Funding

5.1. Funding

SANBAG will be financially responsible for all BMPs, including treatment control BMPs within its ROW. Other stakeholders will be financially responsible for other applicable BMPs within their respective ROW, agency authority or as stipulated by agreement. This is yet to be determined and will be identified in more detail during the PS&E phase.

6. WQMP Certification

6.1. Certification

Since this is a Preliminary WQMP, the document does not include the Certification Statement. The signed Certification Statement is only required and is normally included in the Final WQMP for qualified projects under the jurisdiction of the permittees and will be in accordance with the current WQMP template at the time the Final WQMP is prepared. However, since the project proponent is not a permittee, it is not anticipated that the Final WQMP will include a Certification Statement from SANBAG. The Final WQMP will only include a Certification Statement from other stakeholders if those stakeholders are responsible for elements of the Project such as, but not limited to, the stations and the parking lots.

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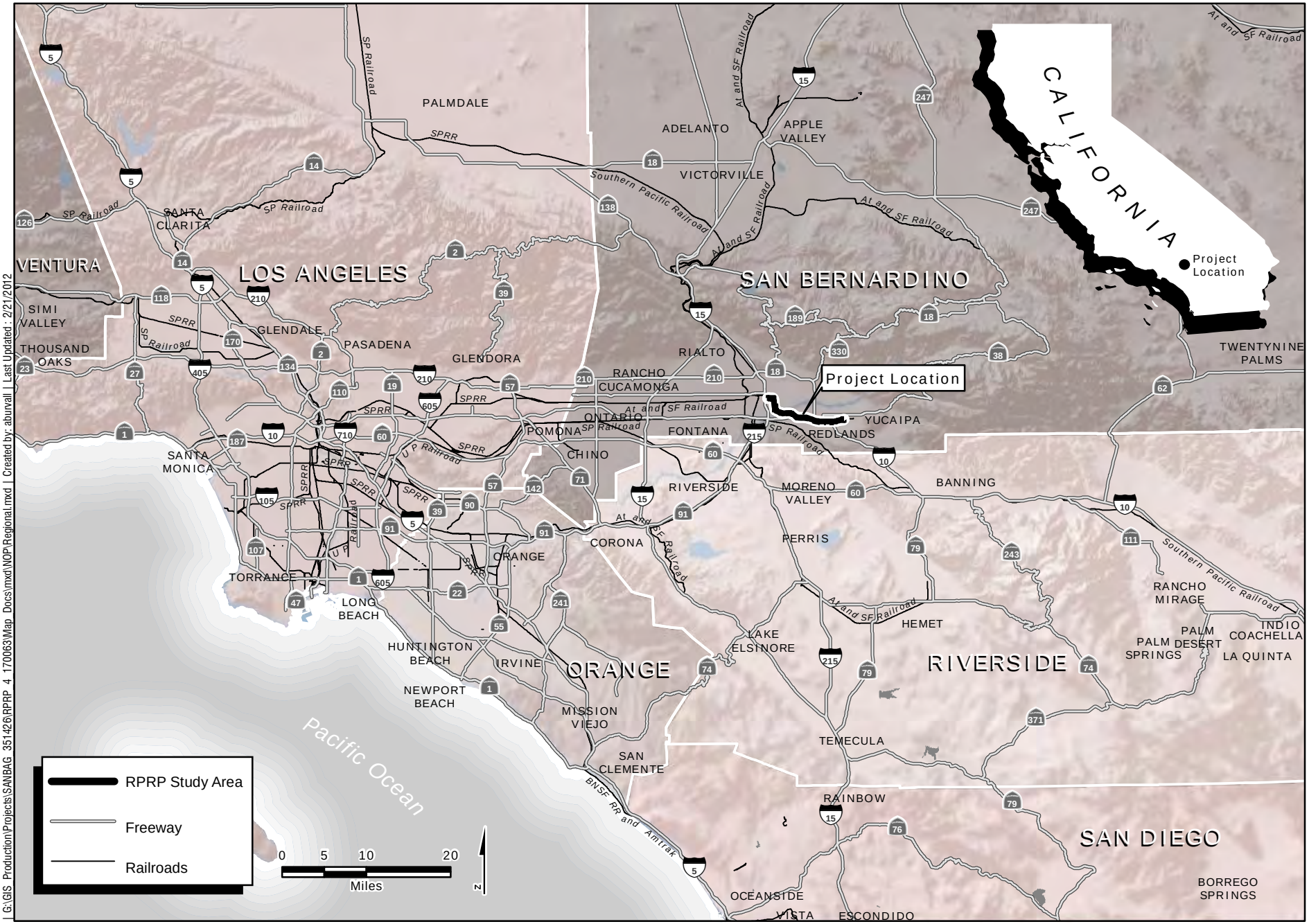
Appendix A
Project Exhibits



Regional Location and Project Area

FIGURE 1

SANBAG/FTA | Redlands Passenger Rail Project | NOP

HDR
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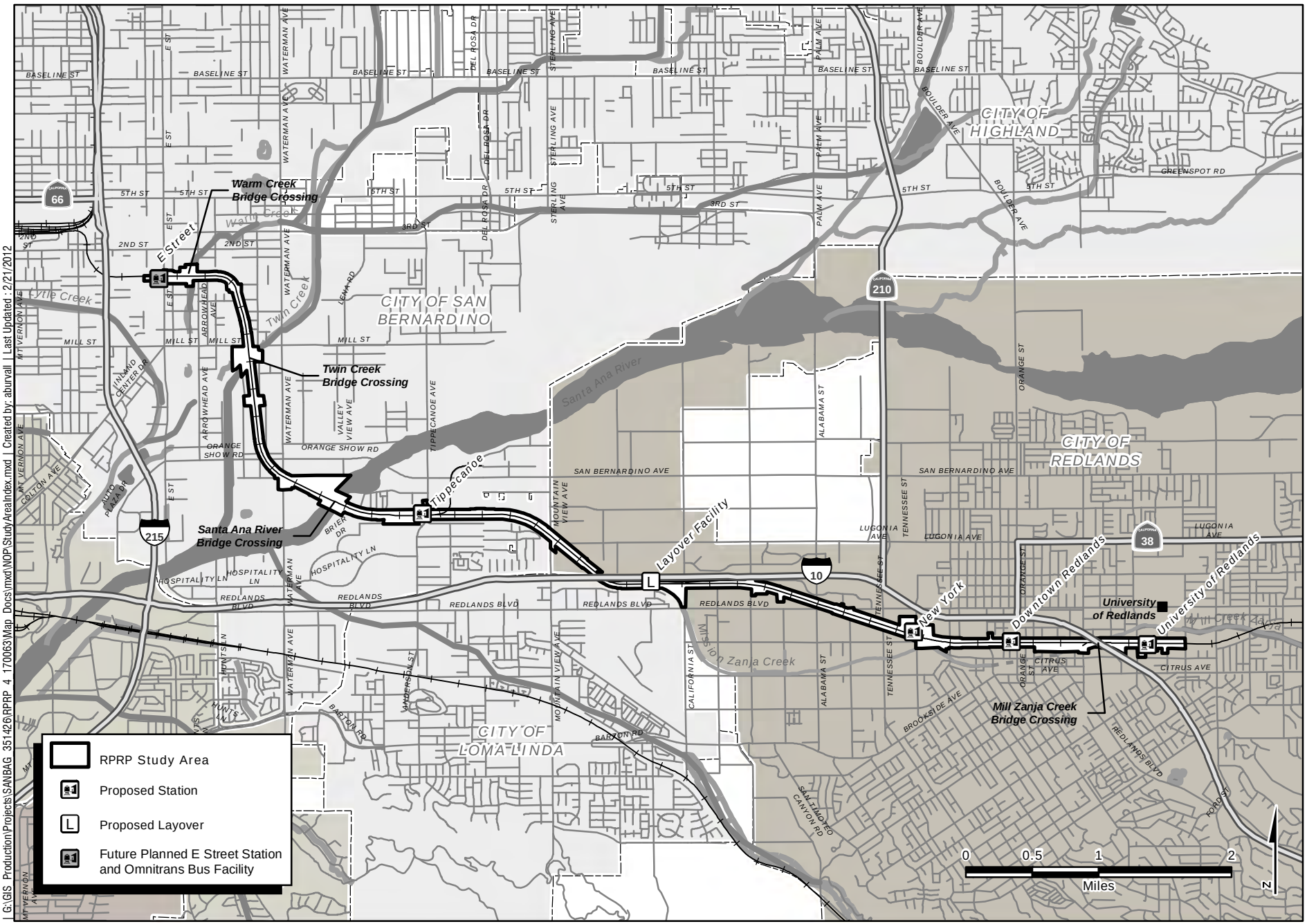

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RPRP Study Area

FIGURE 2

SANBAG | Redlands Passenger Rail Project | NOP

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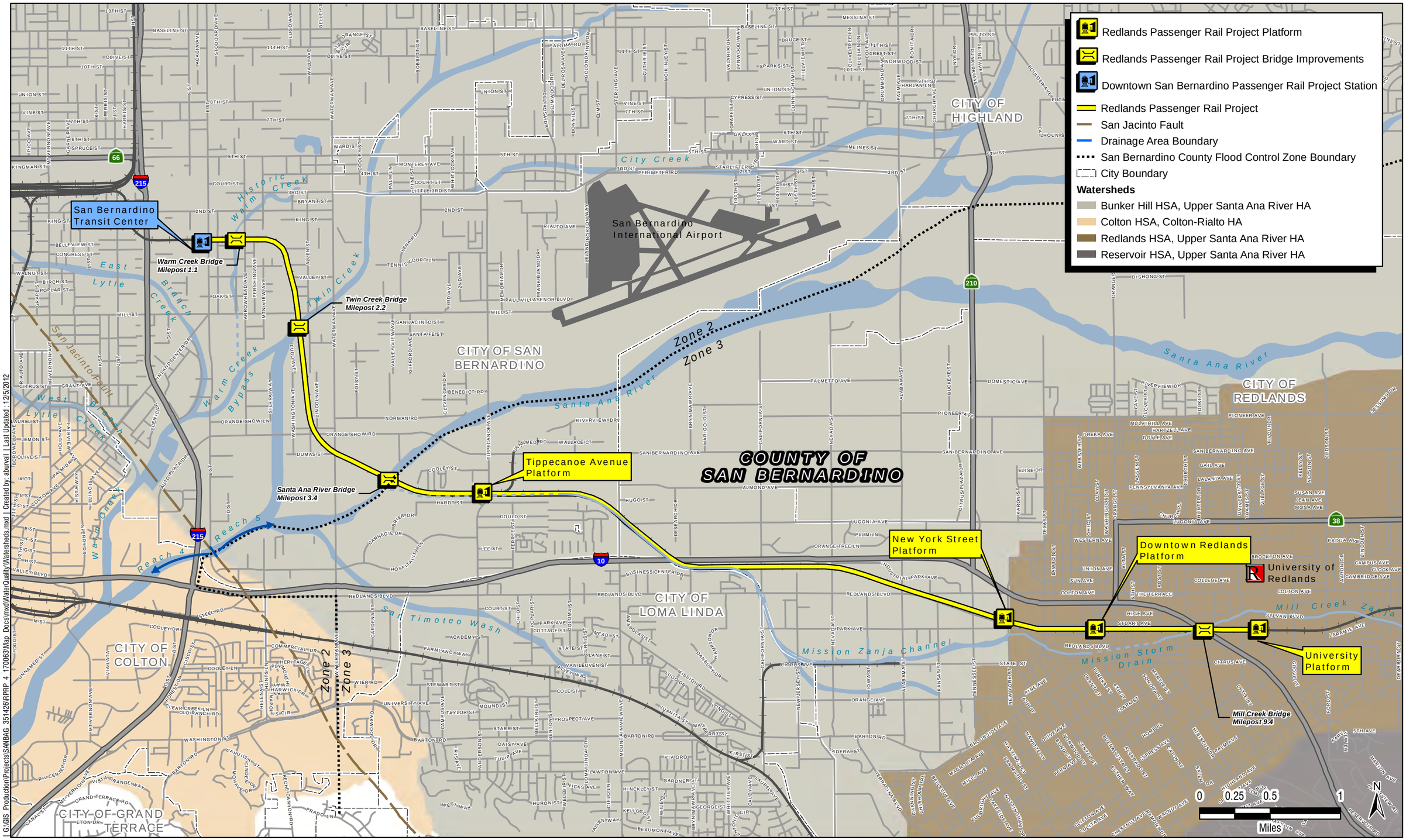

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Watersheds and Surface Waters

FIGURE 3

SANBAG | Redlands Passenger Rail Project

Appendix B
Miscellaneous

National Pollutant Discharge Elimination System (NPDES) Requirements

The City of San Bernardino is subject to National Pollutant Discharge Elimination System (NPDES) permit requirements. The NPDES program stems from the Federal Environmental Protection Agency's (EPA) Clean Water Act Section 402 (p). The purpose of this permit is to help protect the beneficial uses of receiving waters (in this case the Santa Ana River and all its tributaries) from urban runoff pollution and hydrological flow degradation.

The EPA has delegated The State Water Resource Control Board to monitor permittee compliance with all NPDES permit requirements. The State Water Resource Control Board has in turn, allocated these responsibilities to the California Regional Water Quality Control Boards.

The City of San Bernardino is under the jurisdiction of the Santa Ana Regional Water Quality Control Board. This Board has stipulated that the City implement and monitor all permit requirements. Therefore, the City of San Bernardino will require all proposed project proponents to review section 1.2 and Table 1-1 of the Water Quality Management Plan (WQMP) guidance manual to determine whether the proponent's project will require the development of a WQMP. Also, all projects meeting at least one of the categories in Table 1-1 must have a preliminary WQMP prepared and reviewed during the planning process. No entitlements will be issued without the approval of the preliminary WQMP. The final WQMP will be included in the conditions of approval for all projects meeting WQMP submittal guidelines and will be reviewed and approved by the City prior to any permit issuance.

The WQMP guidance document and template are located on:

The San Bernardino County Website at:
http://www.co.san-bernardino.ca.us/stormwater/educational_materials.htm
(Scroll down to Reference Material)

or the Santa Ana Regional Water Quality Control Board at:
http://www.waterboards.ca.gov/santaana/water_issues/programs/stormwater/sb_wqmp.shtml

In addition, all projects that do not meet the criteria of "categorical" projects, as described in section 1.2 and Table 1-1 of the WQMP template, will be required to have a "Non-Categorical" WQMP prepared. The Non-Categorical WQMP shall focus on site design and source control pollutant prevention measures. The Non-Categorical WQMP template can be found on the City website at: http://www.sbcity.org/depts/devserv/public_works/storm_water_requirements.asp

Please be aware that a WQMP is not a Storm Water Pollution Prevention Plan (SWPPP). A SWPPP only covers the constructional phase of a project; whereas, a WQMP focuses on post-construction water quality protection through the use of site design, source control, and treatment control Best Management Practices (BMPs).

Also, please note the City of San Bernardino will not authorize nor will it accept fiscal responsibility, maintenance or liability for any site, source or treatment control BMP(s) in the

City's right-of-way. All structural BMPs must be placed on the project proponent(s) own property.

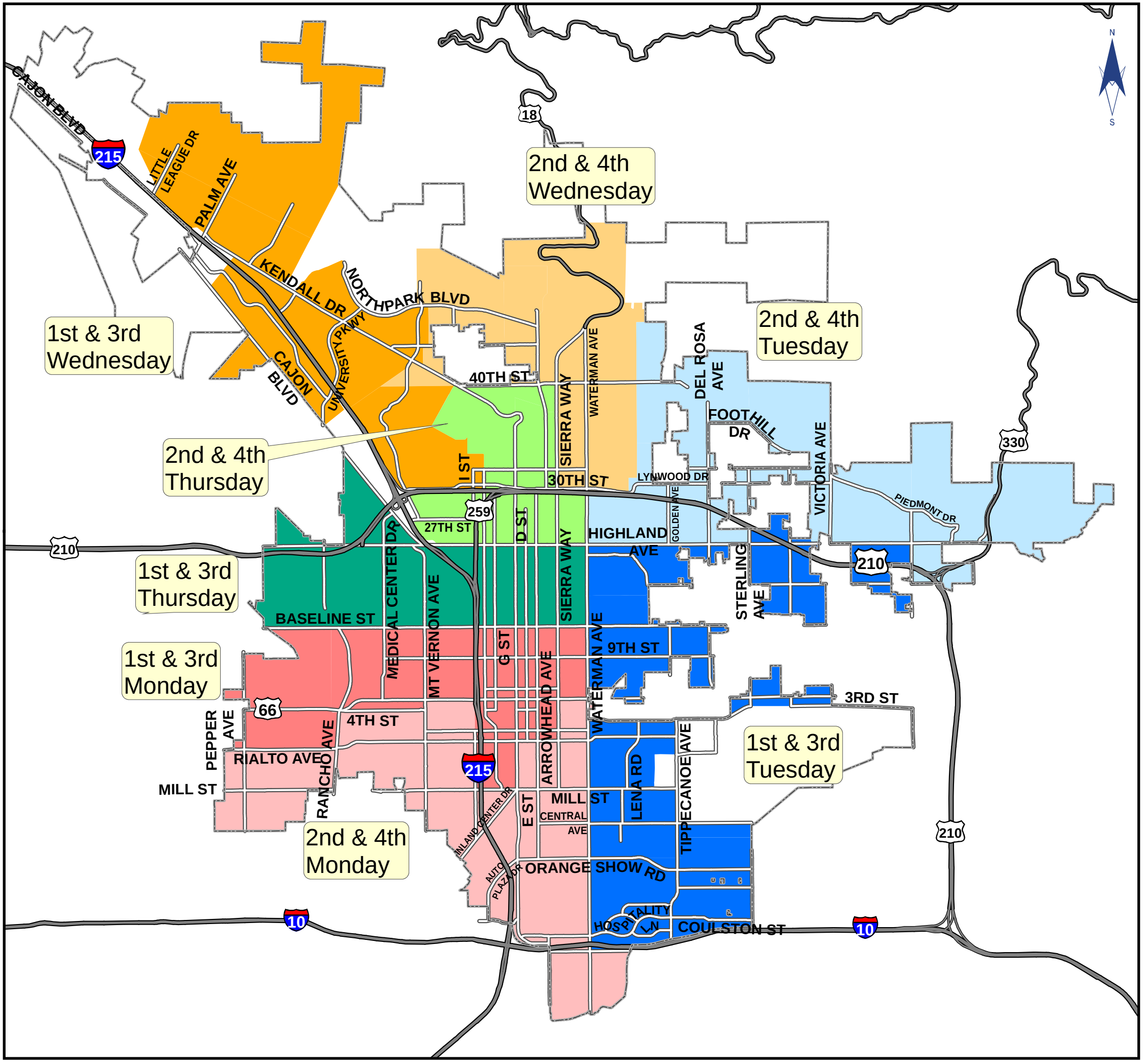
The Regional Water Quality Control Board requires all construction projects over one acre to obtain coverage under the statewide general construction permit. The production of a SWPPP is a requirement of the general construction permit and the City will review the SWPPP before any permits are issued. The City asks project proponents to follow the SWPPP template and production guidelines located in the California Stormwater Quality Association (CASQA) Construction Best Management Practices Handbook.

This information can be located at:
http://www.cabmphandbooks.com/Construction.asp

(Scroll to bottom of the page for SWPPP template and guidelines)

For projects under one acre (including demolition projects) an erosion//waste management control plan that delineates all proposed BMPs will be required and will be reviewed by City staff before permits are issued.

For further information on WQMPs or SWPPPs contact Jennifer Shepardson, Development Services Department, at (909) 384-5154 or Shepardson_Je@SBCity.org



CITY OF SAN BERNARDINO

S t r e e t S w e e p i n g

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Appendix C
CASQA BMP Fact Sheets

Vortex Separator MP-51

Description

Vortex separators: (alternatively, swirl concentrators) are gravity separators, and in principle are essentially wet vaults. The difference from wet vaults, however, is that the vortex separator is round, rather than rectangular, and the water moves in a centrifugal fashion before exiting. By having the water move in a circular fashion, rather than a straight line as is the case with a standard wet vault, it is possible to obtain significant removal of suspended sediments and attached pollutants with less space. Vortex separators were originally developed for combined sewer overflows (CSOs), where it is used primarily to remove coarse inorganic solids. Vortex separation has been adapted to stormwater treatment by several manufacturers.

California Experience

There are currently about 100 installations in California.

Advantages

- May provide the desired performance in less space and therefore less cost.
- May be more cost-effective pre-treatment devices than traditional wet or dry basins.
- Mosquito control may be less of an issue than with traditional wet basins.

Limitations

- As some of the systems have standing water that remains between storms, there is concern about mosquito breeding.
- It is likely that vortex separators are not as effective as wet vaults at removing fine sediments, on the order 50 to 100 microns in diameter and less.
- The area served is limited by the capacity of the largest models.
- As the products come in standard sizes, the facilities will be oversized in many cases relative to the design treatment storm, increasing the cost.
- The non-steady flows of stormwater decreases the efficiency of vortex separators from what may be estimated or determined from testing under constant flow.
- Do not remove dissolved pollutants.

Design Considerations

- Service Area
- Settling Velocity
- Appropriate Sizing
- Inlet Pipe Diameter

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	
☑	Metals	●
	Bacteria	
☑	Oil and Grease	
☑	Organics	

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

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- A loss of dissolved pollutants may occur as accumulated organic matter (e.g., leaves) decomposes in the units.

Design and Sizing Guidelines

The stormwater enters, typically below the effluent line, tangentially into the basin, thereby imparting a circular motion in the system. Due to centrifugal forces created by the circular motion, the suspended particles move to the center of the device where they settle to the bottom. There are two general types of vortex separation: free vortex and dampened (or impeded) vortex. Free vortex separation becomes dampened vortex separation by the placement of radial baffles on the weir-plate that impede the free vortex-flow pattern

It has been stated with respect to CSOs that the practical lower limit of vortex separation is a particle with a settling velocity of 12 to 16.5 feet per hour (0.10 to 0.14 cm/s). As such, the focus for vortex separation in CSOs has been with settleable solids generally 200 microns and larger, given the presence of the lighter organic solids. For inorganic sediment, the above settling velocity range represents a particle diameter of 50 to 100 microns. Head loss is a function of the size of the target particle. At 200 microns it is normally minor but increases significantly if the goal is to remove smaller particles.

The commercial separators applied to stormwater treatment vary considerably with respect to geometry, and the inclusion of radial baffles and internal circular chambers. At one extreme is the inclusion of a chamber within the round concentrator. Water flows initially around the perimeter between the inner and outer chambers, and then into the inner chamber, giving rise to a sudden change in velocity that purportedly enhances removal efficiency. The opposite extreme is to introduce the water tangentially into a round manhole with no internal parts of any kind except for an outlet hood. Whether the inclusion of chambers and baffles gives better performance is unknown. Some contend that free vortex, also identified as swirl concentration, creates less turbulence thereby increasing removal efficiency. One product is unique in that it includes a static separator screen.

- Sized is based on the peak flow of the design treatment event as specified by local government.
- If an in-line facility, the design peak flow is four times the peak of the design treatment event.
- If an off-line facility, the design peak flow is equal to the peak of the design treatment event.
- Headloss differs with the product and the model but is generally on the order of one foot or less in most cases.

Construction/Inspection Considerations

No special considerations.

Performance

Manufacturer's differ with respect to performance claims, but a general statement is that the manufacturer's design and rated capacity (cfs) for each model is based on and believed to achieve an aggregate reduction of 90% of all particles with a specific gravity of 2.65 (glacial sand) down to 150 microns, and to capture the floatables, and oil and grease. Laboratory tests of

two products support this claim. The stated performance expectation therefore implies that a lesser removal efficiency is obtained with particles less than 150 microns, and the lighter, organic settleables. Laboratory tests of one of the products found about 60% removal of 50 micron sand at the expected average operating flow rate

Experience with the use of vortex separators for treating combined sewer overflows (CSOs), the original application of this technology, suggests that the lower practical limit for particle removal are particles with a settling velocity of 12 feet per hour (Sullivan, 1982), which represents a particle diameter of 100 to 200 microns, depending on the specific gravity of the particle. The CSO experience therefore seems consistent with the limited experience with treating stormwater, summarized above

Traditional treatment technologies such as wet ponds and extended detention basins are generally believed to be more effective at removing very small particles, down to the range of 10 to 20 microns. Hence, it is intuitively expected that vortex separators do not perform as well as the traditional wet and dry basins, and filters. Whether this matters depends on the particle size distribution of the sediments in stormwater. If the distribution leans towards small material, there should be a marked difference between vortex separators and, say, traditional wet vaults. There are little data to support this conjecture

In comparison to other treatment technologies, such as wet ponds and grass swales, there are few studies of vortex separators. Only two of manufactured products currently available have been field tested. Two field studies have been conducted. Both achieved in excess of 80% removal of TSS. However, the test was conducted in the Northeast (New York state and Maine) where it is possible the stormwater contained significant quantities of deicing sand. Consequently, the influent TSS concentrations and particle size are both likely considerably higher than is found in California stormwater. These data suggest that if the stormwater particles are for the most part fine (i.e., less than 50 microns), vortex separators will not be as efficient as traditional treatment BMPs such as wet ponds and swales, if the latter are sized according to the recommendations of this handbook.

There are no equations that provide a straightforward determination of efficiency as a function of unit configuration and size. Design specifications of commercial separators are derived from empirical equations that are unique and proprietary to each manufacturer. However, some general relationships between performance and the geometry of a separator have been developed. CSO studies have found that the primary determinants of performance of vortex separators are the diameters of the inlet pipe and chamber with all other geometry proportional to these two.

Sullivan et al. (1982) found that performance is related to the ratios of chamber to inlet diameters, D2/D1, and height between the inlet and outlet and the inlet diameter, H1/D1, shown in Figure 3. The relationships are: as D2/D1 approaches one, the efficiency decreases; and, as the H1/D1 ratio decreases, the efficiency decreases. These relationships may allow qualitative comparisons of the alternative designs of manufacturers. Engineers who wish to apply these concepts should review relevant publications presented in the References.

Siting Criteria

There are no particularly unique siting criteria. The size of the drainage area that can be served by vortex separators is directly related to the capacities of the largest models.

Additional Design Guidelines

Vortex separators have two capacities if positioned as in-line facilities, a treatment capacity and a hydraulic capacity. Failure to recognize the difference between the two may lead to significant under sizing; i.e., too small a model is selected. This observation is relevant to three of the five products. These three technologies all are designed to experience a unit flow rate of about 24 gallons/square foot of separator footprint at the peak of the design treatment event. This is the horizontal area of the separator zone within the container, not the total footprint of the unit. At this unit flow rate, laboratory tests by these manufacturers have established that the performance will meet the general claims previously described. However, the units are sized to handle 100 gallons/square foot at the peak of the hydraulic event. Hence, in selecting a particular model the design engineer must be certain to match the peak flow of the design event to the stated treatment capacity, not the hydraulic capacity. The former is one-fourth the latter. If the unit is positioned as an off-line facility, the model selected is based on the capacity equal to the peak of the design treatment event.

Maintenance

Maintenance consists of the removal of accumulated material with an eductor truck. It may be necessary to remove and dispose the floatables separately due to the presence of petroleum product.

Maintenance Requirements

Remove all accumulated sediment, and litter and other floatables, annually, unless experience indicates the need for more or less frequent maintenance.

Cost

Manufacturers provide costs for the units including delivery. Installation costs are generally on the order of 50 to 100 % of the manufacturer's cost. For most sites the units are cleaned annually.

Cost Considerations

The different geometry of the several manufactured separators suggests that when comparing the costs of these systems to each other, that local conditions (e.g., groundwater levels) may affect the relative cost-effectiveness.

References and Sources of Additional Information

Field, R., 1972, The swirl concentrator as a combined sewer overflow regulator facility, EPA/R2-72-008, U.S. Environmental Protection Agency, Washington, D.C.

Field, R., D. Averill, T.P. O'Connor, and P. Steel, 1997, Vortex separation technology, Water Qual. Res. J. Canada, 32, 1, 185

Manufacturers technical materials

Sullivan, R.H., et al., 1982, Design manual – swirl and helical bend pollution control devices, EPA-600/8-82/013, U.S. Environmental Protection Agency, Washington, D.C.

Sullivan, R.H., M.M. Cohn, J.E. Ure, F.F. Parkinson, and G. Caliana, 1974, Relationship between diameter and height for the design of a swirl concentrator as a combined sewer overflow regulator, EPA 670/2-74-039, U.S. Environmental Protection Agency, Washington, D.C.

Sullivan, R.H., M.M. Cohn, J.E. Ure, F.F. Parkinson, and G. Caliana, 1974, The swirl concentrator as a grit separator device, EPA670/2-74-026, U.S. Environmental Protection Agency, Washington, D.C.

Sullivan, R.H., M.M. Cohn, J.E. Ure, F.F. Parkinson, and G. Caliana, 1978, Swirl primary separator device and pilot demonstration, EPA600/2-78-126, U.S. Environmental Protection Agency, Washington, D.C.

Drain Inserts MP-52

Description

Drain inserts are manufactured filters or fabric placed in a drop inlet to remove sediment and debris. There are a multitude of inserts of various shapes and configurations, typically falling into one of three different groups: socks, boxes, and trays. The sock consists of a fabric, usually constructed of polypropylene. The fabric may be attached to a frame or the grate of the inlet holds the sock. Socks are meant for vertical (drop) inlets. Boxes are constructed of plastic or wire mesh. Typically a polypropylene "bag" is placed in the wire mesh box. The bag takes the form of the box. Most box products are one box; that is, the setting area and filtration through media occur in the same box. Some products consist of one or more trays or mesh grates. The trays may hold different types of media. Filtration media vary by manufacturer. Types include polypropylene, porous polymer, treated cellulose, and activated carbon.

California Experience

The number of installations is unknown but likely exceeds a thousand. Some users have reported that these systems require considerable maintenance to prevent plugging and bypass.

Advantages

- Does not require additional space as inserts as the drain inlets are already a component of the standard drainage systems.
- Easy access for inspection and maintenance.
- As there is no standing water, there is little concern for mosquito breeding.
- A relatively inexpensive retrofit option.

Limitations

Performance is likely significantly less than treatment systems that are located at the end of the drainage system such as ponds and vaults. Usually not suitable for large areas or areas with trash or leaves than can plug the insert.

Design and Sizing Guidelines

Refer to manufacturer's guidelines. Drain inserts come any many configurations but can be placed into three general groups: socks, boxes, and trays. The sock consists of a fabric, usually constructed of polypropylene. The fabric may be attached to a frame or the grate of the inlet holds the sock. Socks are meant for vertical (drop) inlets. Boxes are constructed of plastic or wire mesh. Typically a polypropylene "bag" is placed in the wire mesh box. The bag takes the form of the box. Most box products are

Design Considerations

- Use with other BMPs
- Fit and Seal Capacity within Inlet

Targeted Constituents

- ☑ Sediment
- ☑ Nutrients
- ☑ Trash
- ☑ Metals
- Bacteria
- ☑ Oil and Grease
- ☑ Organics

Removal Effectiveness

See New Development and Redevelopment Handbook-Section 5.

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one box; that is, the setting area and filtration through media occurs in the same box. One manufacturer has a double-box. Stormwater enters the first box where setting occurs. The stormwater flows into the second box where the filter media is located. Some products consist of one or more trays or mesh grates. The trays can hold different types of media. Filtration media vary with the manufacturer: types include polypropylene, porous polymer, treated cellulose, and activated carbon.

Construction/Inspection Considerations

Be certain that installation is done in a manner that makes certain that the stormwater enters the unit and does not leak around the perimeter. Leakage between the frame of the insert and the frame of the drain inlet can easily occur with vertical (drop) inlets.

Performance

Few products have performance data collected under field conditions.

Siting Criteria

It is recommended that inserts be used only for retrofit situations or as pretreatment where other treatment BMPs presented in this section area used.

Additional Design Guidelines

Follow guidelines provided by individual manufacturers.

Maintenance

Likely require frequent maintenance, on the order of several times per year.

Cost

- The initial cost of individual inserts ranges from less than $100 to about $2,000. The cost of using multiple units in curb inlet drains varies with the size of the inlet.
- The low cost of inserts may tend to favor the use of these systems over other, more effective treatment BMPs. However, the low cost of each unit may be offset by the number of units that are required, more frequent maintenance, and the shorter structural life (and therefore replacement).

References and Sources of Additional Information

Hrachovec, R., and G. Minton, 2001, Field testing of a sock-type catch basin insert, Planet CPR, Seattle, Washington

Interagency Catch Basin Insert Committee, Evaluation of Commercially-Available Catch Basin Inserts for the Treatment of Stormwater Runoff from Developed Sites, 1995

Larry Walker Associates, June 1998, NDMP Inlet/In-Line Control Measure Study Report

Manufacturers literature

Santa Monica (City), Santa Monica Bay Municipal Stormwater/Urban Runoff Project - Evaluation of Potential Catch basin Retrofits, Woodward Clyde, September 24, 1998

Woodward Clyde, June 11, 1996, Parking Lot Monitoring Report, Santa Clara Valley Nonpoint Source Pollution Control Program.

Site Design & Landscape Planning SD-10

Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- ☑ Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Each project site possesses unique topographic, hydrologic, and vegetative features, some of which are more suitable for development than others. Integrating and incorporating appropriate landscape planning methodologies into the project design is the most effective action that can be done to minimize surface and groundwater contamination from stormwater.

Approach

Landscape planning should couple consideration of land suitability for urban uses with consideration of community goals and projected growth. Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Design requirements for site design and landscapes planning should conform to applicable standards and specifications of agencies with jurisdiction and be consistent with applicable General Plan and Local Area Plan policies.

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Designing New Installations

Begin the development of a plan for the landscape unit with attention to the following general principles:

- Formulate the plan on the basis of clearly articulated community goals. Carefully identify conflicts and choices between retaining and protecting desired resources and community growth.
- Map and assess land suitability for urban uses. Include the following landscape features in the assessment: wooded land, open unwooded land, steep slopes, erosion-prone soils, foundation suitability, soil suitability for waste disposal, aquifers, aquifer recharge areas, wetlands, floodplains, surface waters, agricultural lands, and various categories of urban land use. When appropriate, the assessment can highlight outstanding local or regional resources that the community determines should be protected (e.g., a scenic area, recreational area, threatened species habitat, farmland, fish run). Mapping and assessment should recognize not only these resources but also additional areas needed for their sustenance.

Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

Conserve Natural Areas during Landscape Planning

If applicable, the following items are required and must be implemented in the site layout during the subdivision design and approval process, consistent with applicable General Plan and Local Area Plan policies:

- Cluster development on least-sensitive portions of a site while leaving the remaining land in a natural undisturbed condition.
- Limit clearing and grading of native vegetation at a site to the minimum amount needed to build lots, allow access, and provide fire protection.
- Maximize trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought tolerant plants.
- Promote natural vegetation by using parking lot islands and other landscaped areas.
- Preserve riparian areas and wetlands.

Maximize Natural Water Storage and Infiltration Opportunities Within the Landscape Unit

- Promote the conservation of forest cover. Building on land that is already deforested affects basin hydrology to a lesser extent than converting forested land. Loss of forest cover reduces interception storage, detention in the organic forest floor layer, and water losses by evapotranspiration, resulting in large peak runoff increases and either their negative effects or the expense of countering them with structural solutions.
- Maintain natural storage reservoirs and drainage corridors, including depressions, areas of permeable soils, swales, and intermittent streams. Develop and implement policies and

regulations to discourage the clearing, filling, and channelization of these features. Utilize them in drainage networks in preference to pipes, culverts, and engineered ditches.

- Evaluating infiltration opportunities by referring to the stormwater management manual for the jurisdiction and pay particular attention to the selection criteria for avoiding groundwater contamination, poor soils, and hydrogeological conditions that cause these facilities to fail. If necessary, locate developments with large amounts of impervious surfaces or a potential to produce relatively contaminated runoff away from groundwater recharge areas.

Protection of Slopes and Channels during Landscape Design

- Convey runoff safely from the tops of slopes.
- Avoid disturbing steep or unstable slopes.
- Avoid disturbing natural channels.
- Stabilize disturbed slopes as quickly as possible.
- Vegetate slopes with native or drought tolerant vegetation.
- Control and treat flows in landscaping and/or other controls prior to reaching existing natural drainage systems.
- Stabilize temporary and permanent channel crossings as quickly as possible, and ensure that increases in run-off velocity and frequency caused by the project do not erode the channel.
- Install energy dissipaters, such as riprap, at the outlets of new storm drains, culverts, conduits, or channels that enter unlined channels in accordance with applicable specifications to minimize erosion. Energy dissipaters shall be installed in such a way as to minimize impacts to receiving waters.
- Line on-site conveyance channels where appropriate, to reduce erosion caused by increased flow velocity due to increases in tributary impervious area. The first choice for linings should be grass or some other vegetative surface, since these materials not only reduce runoff velocities, but also provide water quality benefits from filtration and infiltration. If velocities in the channel are high enough to erode grass or other vegetative linings, riprap, concrete, soil cement, or geo-grid stabilization are other alternatives.
- Consider other design principles that are comparable and equally effective.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Redevelopment may present significant opportunity to add features which had not previously been implemented. Examples include incorporation of depressions, areas of permeable soils, and swales in newly redeveloped areas. While some site constraints may exist due to the status of already existing infrastructure, opportunities should not be missed to maximize infiltration, slow runoff, reduce impervious areas, disconnect directly connected impervious areas.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Stormwater Management Manual for Western Washington, Washington State Department of Ecology, August 2001.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Efficient Irrigation SD-12

Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Irrigation water provided to landscaped areas may result in excess irrigation water being conveyed into stormwater drainage systems.

Approach

Project plan designs for development and redevelopment should include application methods of irrigation water that minimize runoff of excess irrigation water into the stormwater conveyance system.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment. (Detached residential single-family homes are typically excluded from this requirement.)

Design Considerations

Designing New Installations

The following methods to reduce excessive irrigation runoff should be considered, and incorporated and implemented where determined applicable and feasible by the Permittee:

- Employ rain-triggered shutoff devices to prevent irrigation after precipitation.
- Design irrigation systems to each landscape area's specific water requirements.
- Include design featuring flow reducers or shutoff valves triggered by a pressure drop to control water loss in the event of broken sprinkler heads or lines.
- Implement landscape plans consistent with County or City water conservation resolutions, which may include provision of water sensors, programmable irrigation times (for short cycles), etc.

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- Design timing and application methods of irrigation water to minimize the runoff of excess irrigation water into the storm water drainage system.
- Group plants with similar water requirements in order to reduce excess irrigation runoff and promote surface filtration. Choose plants with low irrigation requirements (for example, native or drought tolerant species). Consider design features such as:
  - Using mulches (such as wood chips or bar) in planter areas without ground cover to minimize sediment in runoff
  - Installing appropriate plant materials for the location, in accordance with amount of sunlight and climate, and use native plant materials where possible and/or as recommended by the landscape architect
  - Leaving a vegetative barrier along the property boundary and interior watercourses, to act as a pollutant filter, where appropriate and feasible
  - Choosing plants that minimize or eliminate the use of fertilizer or pesticides to sustain growth
- Employ other comparable, equally effective methods to reduce irrigation water runoff.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Storm Drain Signage SD-13

Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- ☑ Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Waste materials dumped into storm drain inlets can have severe impacts on receiving and ground waters. Posting notices regarding discharge prohibitions at storm drain inlets can prevent waste dumping. Storm drain signs and stencils are highly visible source controls that are typically placed directly adjacent to storm drain inlets.

Approach

The stencil or affixed sign contains a brief statement that prohibits dumping of improper materials into the urban runoff conveyance system. Storm drain messages have become a popular method of alerting the public about the effects of and the prohibitions against waste disposal.

Suitable Applications

Stencils and signs alert the public to the destination of pollutants discharged to the storm drain. Signs are appropriate in residential, commercial, and industrial areas, as well as any other area where contributions or dumping to storm drains is likely.

Design Considerations

Storm drain message markers or placards are recommended at all storm drain inlets within the boundary of a development project. The marker should be placed in clear sight facing toward anyone approaching the inlet from either side. All storm drain inlet locations should be identified on the development site map.

Designing New Installations

The following methods should be considered for inclusion in the project design and show on project plans:

- Provide stenciling or labeling of all storm drain inlets and catch basins, constructed or modified, within the project area with prohibitive language. Examples include "NO DUMPING

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– DRAINS TO OCEAN" and/or other graphical icons to discourage illegal dumping.

- Post signs with prohibitive language and/or graphical icons, which prohibit illegal dumping at public access points along channels and creeks within the project area.

Note - Some local agencies have approved specific signage and/or storm drain message placards for use. Consult local agency stormwater staff to determine specific requirements for placard types and methods of application.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. If the project meets the definition of "redevelopment", then the requirements stated under " designing new installations" above should be included in all project design plans.

Additional Information

Maintenance Considerations

- Legibility of markers and signs should be maintained. If required by the agency with jurisdiction over the project, the owner/operator or homeowner's association should enter into a maintenance agreement with the agency or record a deed restriction upon the property title to maintain the legibility of placards or signs.

Placement

- Signage on top of curbs tends to weather and fade.
- Signage on face of curbs tends to be worn by contact with vehicle tires and sweeper brooms.

Supplemental Information

Examples

- Most MS4 programs have storm drain signage programs. Some MS4 programs will provide stencils, or arrange for volunteers to stencil storm drains as part of their outreach program.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Pervious Pavements SD-20

Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- ☑ Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Pervious paving is used for light vehicle loading in parking areas. The term describes a system comprising a load-bearing, durable surface together with an underlying layered structure that temporarily stores water prior to infiltration or drainage to a controlled outlet. The surface can itself be porous such that water infiltrates across the entire surface of the material (e.g., grass and gravel surfaces, porous concrete and porous asphalt), or can be built up of impermeable blocks separated by spaces and joints, through which the water can drain. This latter system is termed 'permeable' paving. Advantages of pervious pavements is that they reduce runoff volume while providing treatment, and are unobtrusive resulting in a high level of acceptability.

Approach

Attenuation of flow is provided by the storage within the underlying structure or sub base, together with appropriate flow controls. An underlying geotextile may permit groundwater recharge, thus contributing to the restoration of the natural water cycle. Alternatively, where infiltration is inappropriate (e.g., if the groundwater vulnerability is high, or the soil type is unsuitable), the surface can be constructed above an impermeable membrane. The system offers a valuable solution for drainage of spatially constrained urban areas.

Significant attenuation and improvement in water quality can be achieved by permeable pavements, whichever method is used. The surface and subsurface infrastructure can remove both the soluble and fine particulate pollutants that occur within urban runoff. Roof water can be piped into the storage area directly, adding areas from which the flow can be attenuated. Also, within lined systems, there is the opportunity for stored runoff to be piped out for reuse.

Suitable Applications

Residential, commercial and industrial applications are possible. The use of permeable pavement may be restricted in cold regions, arid regions or regions with high wind erosion. There are some specific disadvantages associated with permeable pavement, which are as follows:

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- Permeable pavement can become clogged if improperly installed or maintained. However, this is countered by the ease with which small areas of paving can be cleaned or replaced when blocked or damaged.
- Their application should be limited to highways with low traffic volumes, axle loads and speeds (less than 30 mph limit), car parking areas and other lightly trafficked or non-trafficked areas. Permeable surfaces are currently not considered suitable for adoptable roads due to the risks associated with failure on high speed roads, the safety implications of ponding, and disruption arising from reconstruction.
- When using un-lined, infiltration systems, there is some risk of contaminating groundwater, depending on soil conditions and aquifer susceptibility. However, this risk is likely to be small because the areas drained tend to have inherently low pollutant loadings.
- The use of permeable pavement is restricted to gentle slopes.
- Porous block paving has a higher risk of abrasion and damage than solid blocks.

Design Considerations

Designing New Installations

If the grades, subsoils, drainage characteristics, and groundwater conditions are suitable, permeable paving may be substituted for conventional pavement on parking areas, cul de sacs and other areas with light traffic. Slopes should be flat or very gentle. Scottish experience has shown that permeable paving systems can be installed in a wide range of ground conditions, and the flow attenuation performance is excellent even when the systems are lined.

The suitability of a pervious system at a particular pavement site will, however, depend on the loading criteria required of the pavement.

Where the system is to be used for infiltrating drainage waters into the ground, the vulnerability of local groundwater sources to pollution from the site should be low, and the seasonal high water table should be at least 4 feet below the surface.

Ideally, the pervious surface should be horizontal in order to intercept local rainfall at source. On sloping sites, pervious surfaces may be terraced to accommodate differences in levels.

Design Guidelines

The design of each layer of the pavement must be determined by the likely traffic loadings and their required operational life. To provide satisfactory performance, the following criteria should be considered:

- The subgrade should be able to sustain traffic loading without excessive deformation.
- The granular capping and sub-base layers should give sufficient load-bearing to provide an adequate construction platform and base for the overlying pavement layers.
- The pavement materials should not crack of suffer excessive rutting under the influence of traffic. This is controlled by the horizontal tensile stress at the base of these layers.

There is no current structural design method specifically for pervious pavements. Allowances should be considered the following factors in the design and specification of materials:

- Pervious pavements use materials with high permeability and void space. All the current UK pavement design methods are based on the use of conventional materials that are dense and relatively impermeable. The stiffness of the materials must therefore be assessed.
- Water is present within the construction and can soften and weaken materials, and this must be allowed for.
- Existing design methods assume full friction between layers. Any geotextiles or geomembranes must be carefully specified to minimize loss of friction between layers.
- Porous asphalt loses adhesion and becomes brittle as air passes through the voids. Its durability is therefore lower than conventional materials.

The single sized grading of materials used means that care should be taken to ensure that loss of finer particles between unbound layers does not occur.

Positioning a geotextile near the surface of the pervious construction should enable pollutants to be trapped and retained close to the surface of the construction. This has both advantages and disadvantages. The main disadvantage is that the filtering of sediments and their associated pollutants at this level may hamper percolation of waters and can eventually lead to surface ponding. One advantage is that even if eventual maintenance is required to reinstate infiltration, only a limited amount of the construction needs to be disturbed, since the sub-base below the geotextile is protected. In addition, the pollutant concentration at a high level in the structure allows for its release over time. It is slowly transported in the stormwater to lower levels where chemical and biological processes may be operating to retain or degrade pollutants.

The design should ensure that sufficient void space exists for the storage of sediments to limit the period between remedial works.

- Pervious pavements require a single size grading to give open voids. The choice of materials is therefore a compromise between stiffness, permeability and storage capacity.
- Because the sub-base and capping will be in contact with water for a large part of the time, the strength and durability of the aggregate particles when saturated and subjected to wetting and drying should be assessed.
- A uniformly graded single size material cannot be compacted and is liable to move when construction traffic passes over it. This effect can be reduced by the use of angular crushed rock material with a high surface friction.

In pollution control terms, these layers represent the site of long term chemical and biological pollutant retention and degradation processes. The construction materials should be selected, in addition to their structural strength properties, for their ability to sustain such processes. In general, this means that materials should create neutral or slightly alkaline conditions and they should provide favorable sites for colonization by microbial populations.

Construction/Inspection Considerations

- Permeable surfaces can be laid without cross-falls or longitudinal gradients.
- The blocks should be lain level
- They should not be used for storage of site materials, unless the surface is well protected from deposition of silt and other spillages.
- The pavement should be constructed in a single operation, as one of the last items to be built, on a development site. Landscape development should be completed before pavement construction to avoid contamination by silt or soil from this source.
- Surfaces draining to the pavement should be stabilized before construction of the pavement.
- Inappropriate construction equipment should be kept away from the pavement to prevent damage to the surface, sub-base or sub-grade.

Maintenance Requirements

The maintenance requirements of a pervious surface should be reviewed at the time of design and should be clearly specified. Maintenance is required to prevent clogging of the pervious surface. The factors to be considered when defining maintenance requirements must include:

- Type of use
- Ownership
- Level of trafficking
- The local environment and any contributing catchments

Studies in the UK have shown satisfactory operation of porous pavement systems without maintenance for over 10 years and recent work by Imbe et al. at 9th ICUD, Portland, 2002 describes systems operating for over 20 years without maintenance. However, performance under such regimes could not be guaranteed, Table 1 shows typical recommended maintenance regimes:

Table 1 Typical Recommended Maintenance Regimes	
Activity	**Schedule**
■ Minimize use of salt or grit for de-icing ■ Keep landscaped areas well maintained ■ Prevent soil being washed onto pavement	Ongoing
■ Vacuum clean surface using commercially available sweeping machines at the following times: - End of winter (April) - Mid-summer (July / August) - After Autumn leaf-fall (November)	2/3 x per year
■ Inspect outlets	Annual
■ If routine cleaning does not restore infiltration rates, then reconstruction of part of the whole of a pervious surface may be required. ■ The surface area affected by hydraulic failure should be lifted for inspection of the internal materials to identify the location and extent of the blockage. ■ Surface materials should be lifted and replaced after brush cleaning. Geotextiles may need complete replacement. ■ Sub-surface layers may need cleaning and replacing. ■ Removed silts may need to be disposed of as controlled waste.	As needed (infrequent) Maximum 15-20 years

Permeable pavements are up to 25 % cheaper (or at least no more expensive than the traditional forms of pavement construction), when all construction and drainage costs are taken into account. (Accepting that the porous asphalt itself is a more expensive surfacing, the extra cost of which is offset by the savings in underground pipework etc.) (Niemczynowicz, et al., 1987)

Table 1 gives US cost estimates for capital and maintenance costs of porous pavements (Landphair et al., 2000)

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

Cost Considerations

Permeable pavements are up to 25 % cheaper (or at least no more expensive than the traditional forms of pavement construction), when all construction and drainage costs are taken into account. (Accepting that the porous asphalt itself is a more expensive surfacing, the extra cost of which is offset by the savings in underground pipework etc.) (Niemczynowicz, et al., 1987)

Table 2 gives US cost estimates for capital and maintenance costs of porous pavements (Landphair et al., 2000)

Table 2 Engineer's Estimate for Porous Pavement

Porous Pavement													
Item	Units	Price	Cycles/ Year	Quant. 1 Acre WS	Total	Quant. 2 Acre WS	Total	Quant. 3 Acre WS	Total	Quant. 4 Acre WS	Total	Quant. 5 Acre WS	Total
Grading	SY	$2.00		604	$1,208	1209	$2,418	1812	$3,624	2419	$4,838	3020	$6,040
Paving	SY	$19.00		212	$4,028	424	$8,056	636	$12,084	848	$16,112	1060	$20,140
Excavation	CY	$3.60		201	$724	403	$1,451	604	$2,174	806	$2,902	1008	$3,629
Filter Fabric	SY	$1.15		700	$805	1400	$1,610	2000	$2,300	2800	$3,220	3600	$4,140
Stone Fill	CY	$16.00		201	$3,216	403	$6,448	604	$9,664	806	$12,896	1008	$16,128
Sand	CY	$7.00		100	$700	200	$1,400	300	$2,100	400	$2,800	500	$3,500
Sight Well	EA	$300.00		2	$600	3	$900	4	$1,200	7	$2,100	7	$2,100
Seeding	LF	$0.05		644	$32	1288	$64	1932	$97	2576	$129	3220	$161
Check Dam	CY	$35.00		0	$0	0	$0	0	$0	0	$0	0	$0
Total Construction Costs					**$10,105**		**$19,929**		**$29,619**		**$40,158**		**$49,798**
Construction Costs Amortized for 20 Years					**$505**		**$996**		**$1,481**		**$2,008**		**$2,490**
Annual Maintenance Expense													
Item	Units	Price	Cycles/ Year	Quant. 1 Acre WS	Total	Quant. 2 Acre WS	Total	Quant. 3 Acre WS	Total	Quant. 4 Acre WS	Total	Quant. 5 Acre WS	Total
Sweeping	AC	$250.00	6	1	$1,500	2	$3,000	3	$4,500	4	$6,000	5	$7,500
Washing	AC	$250.00	6	1	$1,500	2	$3,000	3	$4,500	4	$6,000	5	$7,500
Inspection	MH	$20.00	5	5	$100	5	$100	5	$100	5	$100	5	$100
Deep Clean	AC	$450.00	0.5	1	$225	2	$450	3	$675	3.9	$878	5	$1,125
Total Annual Maintenance Expense					**$3,980**		**$7,792**		**$11,651**		**$15,483**		**$19,370**

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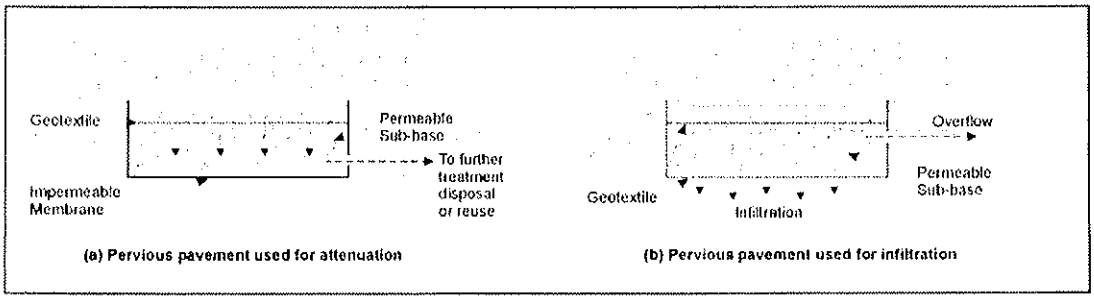

Schematics of a Pervious Pavement System

Alternative Building Materials SD-21

Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Source Control
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutant
- Collect and Convey

Description

Alternative building materials are selected instead of conventional materials for new construction and renovation. These materials reduce potential sources of pollutants in stormwater runoff by eliminating compounds that can leach into runoff, reducing the need for pesticide application, reducing the need for painting and other maintenance, or by reducing the volume of runoff.

Approach

Alternative building materials are available for use as lumber for decking, roofing materials, home siding, and paving for driveways, decks, and sidewalks.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Designing New Installations

Decking

One of the most common materials for construction of decks and other outdoor construction has traditionally been pressure treated wood, which is now being phased out. The standard treatment is called CCA, for chromated copper arsenate. The key ingredients are arsenic (which kills termites, carpenter ants and other insects), copper (which kills the fungi that cause wood to rot) and chromium (which reacts with the other ingredients to bind them to the wood). The amount of arsenic is far from trivial. A deck just 8 feet x 10 feet contains more than 1 1/3 pounds of this highly potent poison. Replacement materials include a new type of pressure treated wood, plastic and composite lumber.

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There are currently over 20 products in the market consisting of plastic or plastic-wood composites. Plastic lumber is made from 100% recycled plastic, # 2 HDPE and polyethylene plastic milk jugs and soap bottles. Plastic-wood composites are a combination of plastic and wood fibers or sawdust. These materials are a long lasting exterior weather, insect, and chemical resistant wood lumber replacement for non structural applications. Use it for decks, docks, raised garden beds and planter boxes, pallets, hand railings, outdoor furniture, animal pens, boat decks, etc.

New pressure treated wood uses a much safer recipe, ACQ, which stands for ammoniacal copper quartenary. It contains no arsenic and no chromium. Yet the American Wood Preservers Association has found it to be just as effective as the standard formula. ACQ is common in Japan and Europe.

Roofing

Several studies have indicated that metal used as roofing material, flashing, or gutters can leach metals into the environment. The leaching occurs because rainfall is slightly acidic and slowly dissolved the exposed metals. Common traditional applications include copper sheathing and galvanized (zinc) gutters.

Coated metal products are available for both roofing and gutter applications. These products eliminate contact of bare metal with rainfall, eliminating one source of metals in runoff. There are also roofing materials made of recycled rubber and plastic that resemble traditional materials.

A less traditional approach is the use of green roofs. These roofs are not just green, they're alive. Planted with grasses and succulents, low- profile green roofs reduce the urban heat island effect, stormwater runoff, and cooling costs, while providing wildlife habitat and a connection to nature for building occupants. These roofs are widely used on industrial facilities in Europe and have been established as experimental installations in several locations in the US, including Portland, Oregon. Their feasibility is questionable in areas of California with prolonged, dry, hot weather.

Paved Areas

Traditionally, concrete is used for construction of patios, sidewalks, and driveways. Although it is non-toxic, these paved areas reduce stormwater infiltration and increase the volume and rate of runoff. This increase in the amount of runoff is the leading cause of stream channel degradation in urban areas.

There are a number of alternative materials that can be used in these applications, including porous concrete and asphalt, modular blocks, and crushed granite. These materials, especially modular paving blocks, are widely available and a well established method to reduce stormwater runoff.

Building Siding

Wood siding is commonly used on the exterior of residential construction. This material weathers fairly rapidly and requires repeated painting to prevent rotting. Alternative "new" products for this application include cement-fiber and vinyl. Cement-fiber siding is a masonry product made from Portland cement, sand, and cellulose and will not burn, cup, swell, or shrink.

Pesticide Reduction
A common use of powerful pesticides is for the control of termites. Chlordane was used for many years for this purpose and is now found in urban streams and lakes nationwide. There are a number of physical barriers that can be installed during construction to help reduce the use of pesticides.

Sand barriers for subterranean termites are a physical deterrent because the termites cannot tunnel through it. Sand barriers can be applied in crawl spaces under pier and beam foundations, under slab foundations, and between the foundation and concrete porches, terraces, patios and steps. Other possible locations include under fence posts, underground electrical cables, water and gas lines, telephone and electrical poles, inside hollow tile cells and against retaining walls.

Metal termite shields are physical barriers to termites which prevent them from building invisible tunnels. In reality, metal shields function as a helpful termite detection device, forcing them to build tunnels on the outside of the shields which are easily seen. Metal termite shields also help prevent dampness from wicking to adjoining wood members which can result in rot, thus making the material more attractive to termites and other pests. Metal flashing and metal plates can also be used as a barrier between piers and beams of structures such as decks, which are particularly vulnerable to termite attack.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of "redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Other Resources

There are no good, independent, comprehensive sources of information on alternative building materials for use in minimizing the impacts of stormwater runoff. Most websites or other references to "green" or "alternative" building materials focus on indoor applications, such as formaldehyde free plywood and low VOC paints, carpets, and pads. Some supplemental information on alternative materials is available from the manufacturers.

Fires are a source of concern in many areas of California. Information on the flammability of alternative decking materials is available from the University of California Forest Product Laboratory (UCFPL) website at: http://www.ucfpl.ucop.edu/WDDeckIntro.htm

Fueling Areas SD-30

Photo Credit: Geoff Brosseau

Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- ☑ Collect and Convey

Description

Fueling areas have the potential to contribute oil and grease, solvents, car battery acid, coolant and gasoline to the stormwater conveyance system. Spills at vehicle and equipment fueling areas can be a significant source of pollution because fuels contain toxic materials and heavy metals that are not easily removed by stormwater treatment devices.

Approach

Project plans must be developed for cleaning near fuel dispensers, emergency spill cleanup, containment, and leak prevention.

Suitable Applications

Appropriate applications include commercial, industrial, and any other areas planned to have fuel dispensing equipment, including retail gasoline outlets, automotive repair shops, and major non-retail dispensing areas.

Design Considerations

Design requirements for fueling areas are governed by Building and Fire Codes and by current local agency ordinances and zoning requirements. Design requirements described in this fact sheet are meant to enhance and be consistent with these code and ordinance requirements.

Designing New Installations

Covering

Fuel dispensing areas should provide an overhanging roof structure or canopy. The cover's minimum dimensions must be equal to or greater than the area within the grade break. The cover must not drain onto the fuel dispensing area and the downspouts must be routed to prevent drainage across the fueling area. The fueling area should drain to the project's treatment control BMP(s) prior to discharging to the stormwater conveyance system. Note - If fueling large equipment or vehicles that would prohibit the use of covers or roofs, the fueling island should be designed to sufficiently accommodate the larger vehicles and equipment and to prevent stormwater run-on and runoff. Grade to direct stormwater to a dead-end sump.

Surfacing

Fuel dispensing areas should be paved with Portland cement concrete (or equivalent smooth impervious surface). The use of asphalt concrete should be prohibited. Use asphalt sealant to protect asphalt paved areas surrounding the fueling area. This provision may be made to sites that have pre-existing asphalt surfaces.

The concrete fuel dispensing area should be extended a minimum of 6.5 ft from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 ft, whichever is less.

Grading/Contouring

Dispensing areas should have an appropriate slope to prevent ponding, and be separated from the rest of the site by a grade break that prevents run-on of urban runoff. (Slope is required to be 2 to 4% in some jurisdictions' stormwater management and mitigation plans.)

Fueling areas should be graded to drain toward a dead-end sump. Runoff from downspouts/roofs should be directed away from fueling areas. Do not locate storm drains in the immediate vicinity of the fueling area.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

- In the case of an emergency, provide storm drain seals, such as isolation valves, drain plugs, or drain covers, to prevent spills or contaminated stormwater from entering the stormwater conveyance system.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Maintenance Bays & Docks SD-31

Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- ☑ Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- Collect and Convey

Description

Several measures can be taken to prevent operations at maintenance bays and loading docks from contributing a variety of toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to the stormwater conveyance system.

Approach

In designs for maintenance bays and loading docks, containment is encouraged. Preventative measures include overflow containment structures and dead-end sumps. However, in the case of loading docks from grocery stores and warehouse/distribution centers, engineered infiltration systems may be considered.

Suitable Applications

Appropriate applications include commercial and industrial areas planned for development or redevelopment.

Design Considerations

Design requirements for vehicle maintenance and repair are governed by Building and Fire Codes, and by current local agency ordinances, and zoning requirements. The design criteria described in this fact sheet are meant to enhance and be consistent with these code requirements.

Designing New Installations

Designs of maintenance bays should consider the following:

- Repair/maintenance bays and vehicle parts with fluids should be indoors; or designed to preclude urban run-on and runoff.
- Repair/maintenance floor areas should be paved with Portland cement concrete (or equivalent smooth impervious surface).

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- Repair/maintenance bays should be designed to capture all wash water leaks and spills. Provide impermeable berms, drop inlets, trench catch basins, or overflow containment structures around repair bays to prevent spilled materials and wash-down waters form entering the storm drain system. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the storm drain system is prohibited. If required by local jurisdiction, obtain an Industrial Waste Discharge Permit.
- Other features may be comparable and equally effective.

The following designs of loading/unloading dock areas should be considered:

- Loading dock areas should be covered, or drainage should be designed to preclude urban run-on and runoff.
- Direct connections into storm drains from depressed loading docks (truck wells) are prohibited.
- Below-grade loading docks from grocery stores and warehouse/distribution centers of fresh food items should drain through water quality inlets, or to an engineered infiltration system, or an equally effective alternative. Pre-treatment may also be required.
- Other features may be comparable and equally effective.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

Stormwater and non-stormwater will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and cannot be discharged directly to the storm drain or sanitary sewer system without the appropriate permit.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Trash Storage Areas SD-32

Description

Trash storage areas are areas where a trash receptacle (s) are located for use as a repository for solid wastes. Stormwater runoff from areas where trash is stored or disposed of can be polluted. In addition, loose trash and debris can be easily transported by water or wind into nearby storm drain inlets, channels, and/or creeks. Waste handling operations that may be sources of stormwater pollution include dumpsters, litter control, and waste piles.

Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- Collect and Convey

Approach

This fact sheet contains details on the specific measures required to prevent or reduce pollutants in stormwater runoff associated with trash storage and handling. Preventative measures including enclosures, containment structures, and impervious pavements to mitigate spills, should be used to reduce the likelihood of contamination.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment. (Detached residential single-family homes are typically excluded from this requirement.)

Design Considerations

Design requirements for waste handling areas are governed by Building and Fire Codes, and by current local agency ordinances and zoning requirements. The design criteria described in this fact sheet are meant to enhance and be consistent with these code and ordinance requirements. Hazardous waste should be handled in accordance with legal requirements established in Title 22, California Code of Regulation.

Wastes from commercial and industrial sites are typically hauled by either public or commercial carriers that may have design or access requirements for waste storage areas. The design criteria in this fact sheet are recommendations and are not intended to be in conflict with requirements established by the waste hauler. The waste hauler should be contacted prior to the design of your site trash collection areas. Conflicts or issues should be discussed with the local agency.

Designing New Installations

Trash storage areas should be designed to consider the following structural or treatment control BMPs:

- Design trash container areas so that drainage from adjoining roofs and pavement is diverted around the area(s) to avoid run-on. This might include berming or grading the waste handling area to prevent run-on of stormwater.
- Make sure trash container areas are screened or walled to prevent off-site transport of trash.

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- Use lined bins or dumpsters to reduce leaking of liquid waste.
- Provide roofs, awnings, or attached lids on all trash containers to minimize direct precipitation and prevent rainfall from entering containers.
- Pave trash storage areas with an impervious surface to mitigate spills.
- Do not locate storm drains in immediate vicinity of the trash storage area.
- Post signs on all dumpsters informing users that hazardous materials are not to be disposed of therein.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

Maintenance Considerations

The integrity of structural elements that are subject to damage (i.e., screens, covers, and signs) must be maintained by the owner/operator. Maintenance agreements between the local agency and the owner/operator may be required. Some agencies will require maintenance deed restrictions to be recorded of the property title. If required by the local agency, maintenance agreements or deed restrictions must be executed by the owner/operator before improvement plans are approved.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Vehicle Washing Areas SD-33

Photo Credit: Geoff Brosseau

Design Objectives

- ☑ Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- ☑ Collect and Convey

Description

Vehicle washing, equipment washing, and steam cleaning may contribute high concentrations of metals, oil and grease, solvents, phosphates, and suspended solids to wash waters that drain to stormwater conveyance systems.

Approach

Project plans should include appropriately designed area(s) for washing-steam cleaning of vehicles and equipment. Depending on the size and other parameters of the wastewater facility, wash water may be conveyed to a sewer, an infiltration system, recycling system or other alternative. Pretreatment may be required for conveyance to a sanitary sewer.

Suitable Applications

Appropriate applications include commercial developments, restaurants, retail gasoline outlets, automotive repair shops and others.

Design Considerations

Design requirements for vehicle maintenance are governed by Building and Fire Codes, and by current local agency ordinances, and zoning requirements. Design criteria described in this fact sheet are meant to enhance and be consistent with these code requirements.

Designing New Installations

Areas for washing/steam cleaning should incorporate one of the following features:

- Be self-contained and/or covered with a roof or overhang
- Be equipped with a clarifier or other pretreatment facility
- Have a proper connection to a sanitary sewer

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- Include other features which are comparable and equally effective

CAR WASH AREAS - Some jurisdictions' stormwater management plans include vehicle-cleaning area source control design requirements for community car wash racks in complexes with a large number of dwelling units. In these cases, wash water from the areas may be directed to the sanitary sewer, to an engineered infiltration system, or to an equally effective alternative. Pre-treatment may also be required.

Depending on the jurisdiction, developers may be directed to divert surface water runoff away from the exposed area around the wash pad (parking lot, storage areas), and wash pad itself to alternatives other than the sanitary sewer. Roofing may be required for exposed wash pads.

It is generally advisable to cover areas used for regular washing of vehicles, trucks, or equipment, surround them with a perimeter berm, and clearly mark them as a designated washing area. Sumps or drain lines can be installed to collect wash water, which may be treated for reuse or recycling, or for discharge to the sanitary sewer. Jurisdictions may require some form of pretreatment, such as a trap, for these areas.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment.

Additional Information

Maintenance Considerations

Stormwater and non-stormwater will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and cannot be discharged directly to the storm drain or sanitary sewer system without the appropriate permit.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

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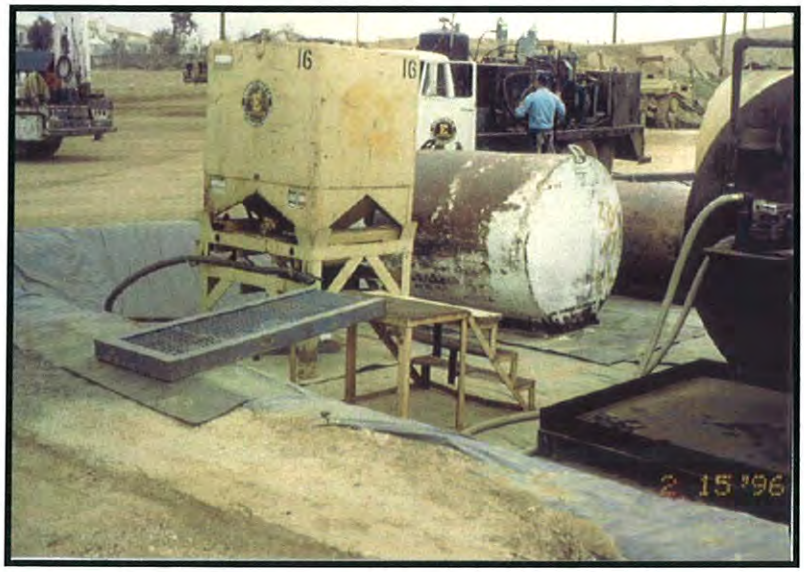
Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Outdoor Material Storage Areas SD-34



Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutant
- Collect and Convey

Description

Proper design of outdoor storage areas for materials reduces opportunity for toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to enter the stormwater conveyance system. Materials may be in the form of raw products, by-products, finished products, and waste products. The type of pollutants associated with the materials will vary depending on the type of commercial or industrial activity.

Approach

Outdoor storage areas require a drainage approach different from the typical infiltration/detention strategy. In outdoor storage areas, infiltration is discouraged. Containment is encouraged. Preventative measures include enclosures, secondary containment structures and impervious surfaces.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Some materials are more of a concern than others. Toxic and hazardous materials must be prevented from coming in contact with stormwater. Non-toxic or non-hazardous materials do not have to be prevented from stormwater contact. However, these materials may have toxic effects on receiving waters if allowed to be discharged with stormwater in significant quantities. Accumulated material on an impervious surface could result in significant impact on the rivers or streams that receive the runoff.

Material may be stored in a variety of ways, including bulk piles, containers, shelving, stacking, and tanks. Stormwater contamination may be prevented by eliminating the possibility of stormwater contact with the material storage areas either through diversion, cover, or capture of the stormwater. Control measures may also include minimizing the storage area. Design

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requirements for material storage areas are governed by Building and Fire Codes, and by current City or County ordinances and zoning requirements. Control measures are site specific, and must meet local agency requirements.

Designing New Installations

Where proposed project plans include outdoor areas for storage of materials that may contribute pollutants to the stormwater conveyance system, the following structural or treatment BMPS should be considered:

- Materials with the potential to contaminate stormwater should be: (1) placed in an enclosure such as, but not limited to, a cabinet, shed, or similar structure that prevents contact with runoff or spillage to the stormwater conveyance system, or (2) protected by secondary containment structures such as berms, dikes, or curbs.
- The storage area should be paved and sufficiently impervious to contain leaks and spills.
- The storage area should slope towards a dead-end sump to contain spills and direct runoff from downspouts/roofs should be directed away from storage areas.
- The storage area should have a roof or awning that extends beyond the storage area to minimize collection of stormwater within the secondary containment area. A manufactured storage shed may be used for small containers.

Note that the location(s) of installations of where these preventative measures will be employed must be included on the map or plans identifying BMPs.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

Stormwater and non-stormwater will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and cannot be discharged directly to the storm drain or sanitary sewer system without the appropriate permits.

Other Resources

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Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Outdoor Work Areas SD-35

Photo Credit: Geoff Brosseau

Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutant
- ☑ Collect and Convey

Description

Proper design of outdoor work areas for materials reduces opportunity for toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to enter the stormwater conveyance system.

Approach

Outdoor work areas require a drainage approach different from the typical infiltration/detention strategy. In outdoor work areas, infiltration is discouraged; collection and conveyance are encouraged. In outdoor work areas, infiltration is discouraged and runoff is often routed directly to the sanitary sewer, not the storm drain. Because this runoff is being added to the loads normally received by the wastewater treatment plants, municipal stormwater programs and/or private developers must work with the local plant to develop solutions that minimize effects on the treatment facility. These concerns are best addressed in the planning and design stage of the outdoor work area.

Suitable Applications

Appropriate applications include residential, commercial, and industrial areas planned for development or redevelopment.

Design Considerations

Design requirements for outdoor work areas are governed by Building and Fire Codes, and by current local agency ordinances, and zoning requirements.

Designing New Installations

Outdoor work areas can be designed in particular ways to reduce impacts on both stormwater quality and sewage treatment plants.

- Create an impermeable surface such as concrete or asphalt, or a prefabricated metal drip pan, depending on the use.

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- Cover the area with a roof. This prevents rain from falling on the work area and becoming polluted runoff.
- Berm or perform mounding around the perimeter of the area to prevent water from adjacent areas from flowing on to the surface of the work area.
- Directly connect runoff. Unlike other areas, runoff from work areas is directly connected to the sanitary sewer or other specialized containment system(s). This allows the more highly concentrated pollutants from these areas to receive special treatment that removes particular constituents. Approval for this connection must be obtained from the appropriate sanitary sewer agency.
- Locate the work area away from storm drains or catch basins.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

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Outdoor Processing Areas SD-36

Description

Outdoor process equipment operations such as rock grinding or crushing, painting or coating, grinding or sanding, degreasing or parts cleaning, landfills, waste piles, wastewater and solid waste treatment and disposal, and others operations may contribute a variety of toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to the storm conveyance system.

Approach

Outdoor processing areas require a drainage approach different from the typical infiltration/detention strategy. In outdoor process equipment areas, infiltration is discouraged. Containment is encouraged, accompanied by collection and conveyance. Preventative measures include enclosures, secondary containment structures, dead-end sumps, and conveyance to treatment facilities in accordance with conditions established by the applicable sewer agency.

Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- ☑ Collect and Convey

Suitable Applications

Appropriate applications include commercial and industrial areas planned for development or redevelopment.

Design Considerations

Design requirements for outdoor processing areas are governed by Building and Fire codes, and by current local agency ordinances, and zoning requirements.

Designing New Installations

Operations determined to be a potential threat to water quality should consider to the following recommendations:

- Cover or enclose areas that would be the most significant source of pollutants; or slope the area toward a dead-end sump; or, discharge to the sanitary sewer system following appropriate treatment in accordance with conditions established by the applicable sewer agency.
- Grade or berm area to prevent run-on from surrounding areas.
- Do not install storm drains in areas of equipment repair.
- Consider other features that are comparable or equally effective.
- Provide secondary containment structures (not double wall containers) where wet material processing occurs (e.g., electroplating), to hold spills resulting from accidents, leaking tanks, or equipment, or any other unplanned releases (Note:

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if these are plumbed to the sanitary sewer, they must be with the prior approval of the sewering agency.)

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

Stormwater and non-stormwater will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and cannot be discharged directly to the storm drain or sanitary sewer system without the appropriate permit.

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Infiltration Trench TC-10

Design Considerations

- Accumulation of Metals
- Clogged Soil Outlet Structures
- Vegetation/Landscape Maintenance

Description

An infiltration trench is a long, narrow, rock-filled trench with no outlet that receives stormwater runoff. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. Infiltration trenches perform well for removal of fine sediment and associated pollutants. Pretreatment using buffer strips, swales, or detention basins is important for limiting amounts of coarse sediment entering the trench which can clog and render the trench ineffective.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	■
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

California Experience

Caltrans constructed two infiltration trenches at highway maintenance stations in Southern California. Of these, one failed to operate to the design standard because of average soil infiltration rates lower than that measured in the single infiltration test. This highlights the critical need for appropriate evaluation of the site. Once in operation, little maintenance was required at either site.

Advantages

- Provides 100% reduction in the load discharged to surface waters.
- An important benefit of infiltration trenches is the approximation of pre-development hydrology during which a significant portion of the average annual rainfall runoff is infiltrated rather than flushed directly to creeks.
- If the water quality volume is adequately sized, infiltration trenches can be useful for providing control of channel forming (erosion) and high frequency (generally less than the 2-year) flood events.

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- As an underground BMP, trenches are unobtrusive and have little impact of site aesthetics.

Limitations

- Have a high failure rate if soil and subsurface conditions are not suitable.
- May not be appropriate for industrial sites or locations where spills may occur.
- The maximum contributing area to an individual infiltration practice should generally be less than 5 acres.
- Infiltration basins require a minimum soil infiltration rate of 0.5 inches/hour, not appropriate at sites with Hydrologic Soil Types C and D.
- If infiltration rates exceed 2.4 inches/hour, then the runoff should be fully treated prior to infiltration to protect groundwater quality.
- Not suitable on fill sites or steep slopes.
- Risk of groundwater contamination in very coarse soils.
- Upstream drainage area must be completely stabilized before construction.
- Difficult to restore functioning of infiltration trenches once clogged.

Design and Sizing Guidelines

- Provide pretreatment for infiltration trenches in order to reduce the sediment load. Pretreatment refers to design features that provide settling of large particles before runoff reaches a management practice, easing the long-term maintenance burden. Pretreatment is important for all structural stormwater management practices, but it is particularly important for infiltration practices. To ensure that pretreatment mechanisms are effective, designers should incorporate practices such as grassed swales, vegetated filter strips, detention, or a plunge pool in series.
- Specify locally available trench rock that is 1.5 to 2.5 inches in diameter.
- Determine the trench volume by assuming the WQV will fill the void space based on the computed porosity of the rock matrix (normally about 35%).
- Determine the bottom surface area needed to drain the trench within 72 hr by dividing the WQV by the infiltration rate.

$$d = \frac{WQV + RFV}{SA}$$

- Calculate trench depth using the following equation:

where:

D = Trench depth

WQV	=	Water quality volume
RFV	=	Rock fill volume
SA	=	Surface area of the trench bottom

- The use of vertical piping, either for distribution or infiltration enhancement shall not be allowed to avoid device classification as a Class V injection well per 40 CFR146.5(e)(4).
- Provide observation well to allow observation of drain time.
- May include a horizontal layer of filter fabric just below the surface of the trench to retain sediment and reduce the potential for clogging.

Construction/Inspection Considerations

Stabilize the entire area draining to the facility before construction begins. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction. Stabilize the entire contributing drainage area before allowing any runoff to enter once construction is complete.

Performance

Infiltration trenches eliminate the discharge of the water quality volume to surface receiving waters and consequently can be considered to have 100% removal of all pollutants within this volume. Transport of some of these constituents to groundwater is likely, although the attenuation in the soil and subsurface layers will be substantial for many constituents.

Infiltration trenches can be expected to remove up to 90 percent of sediments, metals, coliform bacteria and organic matter, and up to 60 percent of phosphorus and nitrogen in the infiltrated runoff (Schueler, 1992). Biochemical oxygen demand (BOD) removal is estimated to be between 70 to 80 percent. Lower removal rates for nitrate, chlorides and soluble metals should be expected, especially in sandy soils (Schueler, 1992). Pollutant removal efficiencies may be improved by using washed aggregate and adding organic matter and loam to the subsoil. The stone aggregate should be washed to remove dirt and fines before placement in the trench. The addition of organic material and loam to the trench subsoil may enhance metals removal through adsorption.

Siting Criteria

The use of infiltration trenches may be limited by a number of factors, including type of native soils, climate, and location of groundwater table. Site characteristics, such as excessive slope of the drainage area, fine-grained soil types, and proximate location of the water table and bedrock, may preclude the use of infiltration trenches. Generally, infiltration trenches are not suitable for areas with relatively impermeable soils containing clay and silt or in areas with fill.

As with any infiltration BMP, the potential for groundwater contamination must be carefully considered, especially if the groundwater is used for human consumption or agricultural purposes. The infiltration trench is not suitable for sites that use or store chemicals or hazardous materials unless hazardous and toxic materials are prevented from entering the trench. In these areas, other BMPs that do not allow interaction with the groundwater should be considered.

The potential for spills can be minimized by aggressive pollution prevention measures. Many municipalities and industries have developed comprehensive spill prevention control and countermeasure (SPCC) plans. These plans should be modified to include the infiltration trench and the contributing drainage area. For example, diversion structures can be used to prevent spills from entering the infiltration trench. Because of the potential to contaminate groundwater, extensive site investigation must be undertaken early in the site planning process to establish site suitability for the installation of an infiltration trench.

Longevity can be increased by careful geotechnical evaluation prior to construction and by designing and implementing an inspection and maintenance plan. Soil infiltration rates and the water table depth should be evaluated to ensure that conditions are satisfactory for proper operation of an infiltration trench. Pretreatment structures, such as a vegetated buffer strip or water quality inlet, can increase longevity by removing sediments, hydrocarbons, and other materials that may clog the trench. Regular maintenance, including the replacement of clogged aggregate, will also increase the effectiveness and life of the trench.

Evaluation of the viability of a particular site is the same as for infiltration basins and includes:

- Determine soil type (consider RCS soil type 'A, B or C' only) from mapping and consult USDA soil survey tables to review other parameters such as the amount of silt and clay, presence of a restrictive layer or seasonal high water table, and estimated permeability. The soil should not have more than 30 percent clay or more than 40 percent of clay and silt combined. Eliminate sites that are clearly unsuitable for infiltration.

- Groundwater separation should be at least 3 m from the basin invert to the measured ground water elevation. There is concern at the state and regional levels of the impact on groundwater quality from infiltrated runoff, especially when the separation between groundwater and the surface is small.

- Location away from buildings, slopes and highway pavement (greater than 6 m) and wells and bridge structures (greater than 30 m). Sites constructed of fill, having a base flow or with a slope greater than 15 percent should not be considered.

- Ensure that adequate head is available to operate flow splitter structures (to allow the basin to be offline) without ponding in the splitter structure or creating backwater upstream of the splitter.

- Base flow should not be present in the tributary watershed.

Secondary Screening Based on Site Geotechnical Investigation

- At least three in-hole conductivity tests shall be performed using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring), two tests at different locations within the proposed basin and the third down gradient by no more than approximately 10 m. The tests shall measure permeability in the side slopes and the bed within a depth of 3 m of the invert.

- The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 13 mm/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.

- Exclude from consideration sites constructed in fill or partially in fill unless no silts or clays are present in the soil boring. Fill tends to be compacted, with clays in a dispersed rather than flocculated state, greatly reducing permeability.
- The geotechnical investigation should be such that a good understanding is gained as to how the stormwater runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

Maintenance

Infiltration trenches required the least maintenance of any of the BMPs evaluated in the Caltrans study, with approximately 17 field hours spent on the operation and maintenance of each site. Inspection of the infiltration trench was the largest field activity, requiring approximately 8 hr/yr.

In addition to reduced water quality performance, clogged infiltration trenches with surface standing water can become a nuisance due to mosquito breeding. If the trench takes more than 72 hours to drain, then the rock fill should be removed and all dimensions of the trench should be increased by 2 inches to provide a fresh surface for infiltration.

Cost

Construction Cost

Infiltration trenches are somewhat expensive, when compared to other stormwater practices, in terms of cost per area treated. Typical construction costs, including contingency and design costs, are about $5 per ft^3 of stormwater treated (SWRPC, 1991; Brown and Schueler, 1997). Actual construction costs may be much higher. The average construction cost of two infiltration trenches installed by Caltrans in southern California was about $50/ft^3; however, these were constructed as retrofit installations.

Infiltration trenches typically consume about 2 to 3 percent of the site draining to them, which is relatively small. In addition, infiltration trenches can fit into thin, linear areas. Thus, they can generally fit into relatively unusable portions of a site.

Maintenance Cost

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly sited or maintained, infiltration trenches have a high failure rate. In general, maintenance costs for infiltration trenches are estimated at between 5 percent and 20 percent of the construction cost. More realistic values are probably closer to the 20-percent range, to ensure long-term functionality of the practice.

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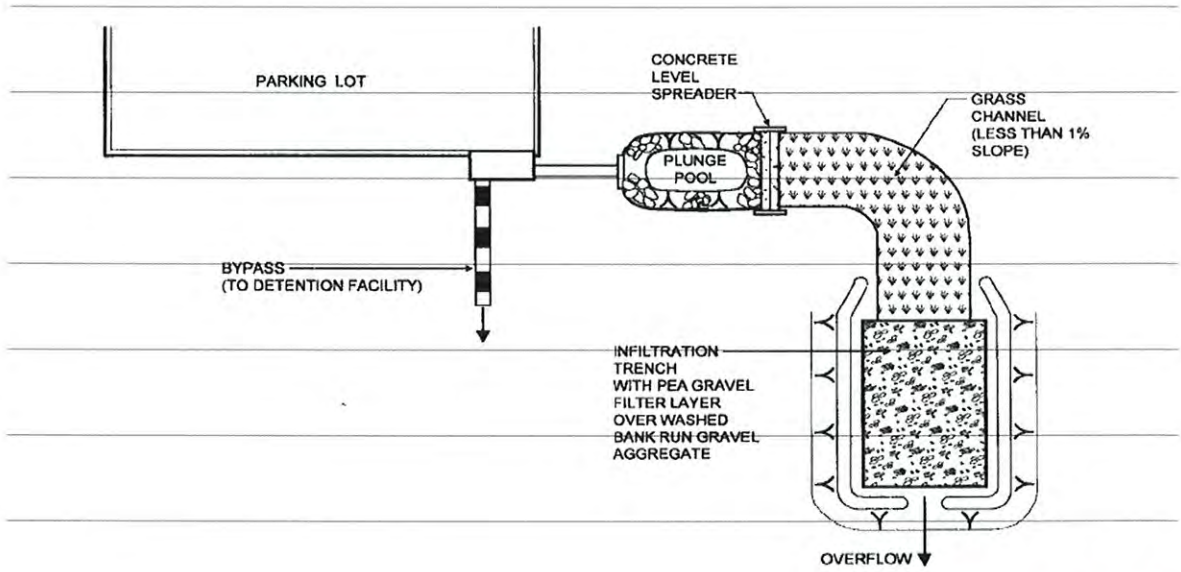
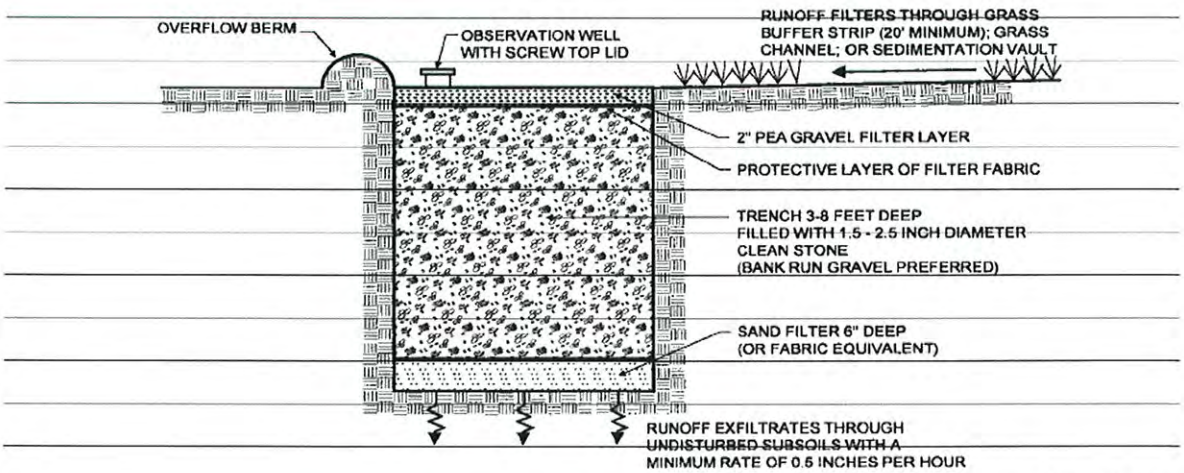
Infiltration Trench TC-10



PLAN VIEW



SECTION

Infiltration Basin TC-11

Design Considerations

- Soil for Infiltration
- Slope
- Aesthetics

Targeted Constituents

☑	Sediment	■
☑	Nutrients	■
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

Description

An infiltration basin is a shallow impoundment that is designed to infiltrate stormwater. Infiltration basins use the natural filtering ability of the soil to remove pollutants in stormwater runoff. Infiltration facilities store runoff until it gradually exfiltrates through the soil and eventually into the water table. This practice has high pollutant removal efficiency and can also help recharge groundwater, thus helping to maintain low flows in stream systems. Infiltration basins can be challenging to apply on many sites, however, because of soils requirements. In addition, some studies have shown relatively high failure rates compared with other management practices.

California Experience

Infiltration basins have a long history of use in California, especially in the Central Valley. Basins located in Fresno were among those initially evaluated in the National Urban Runoff Program and were found to be effective at reducing the volume of runoff, while posing little long-term threat to groundwater quality (EPA, 1983; Schroeder, 1995). Proper siting of these devices is crucial as underscored by the experience of Caltrans in siting two basins in Southern California. The basin with marginal separation from groundwater and soil permeability failed immediately and could never be rehabilitated.

Advantages

- Provides 100% reduction in the load discharged to surface waters.
- The principal benefit of infiltration basins is the approximation of pre-development hydrology during which a

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significant portion of the average annual rainfall runoff is infiltrated and evaporated rather than flushed directly to creeks.

- If the water quality volume is adequately sized, infiltration basins can be useful for providing control of channel forming (erosion) and high frequency (generally less than the 2-year) flood events.

Limitations

- May not be appropriate for industrial sites or locations where spills may occur.
- Infiltration basins require a minimum soil infiltration rate of 0.5 inches/hour, not appropriate at sites with Hydrologic Soil Types C and D.
- If infiltration rates exceed 2.4 inches/hour, then the runoff should be fully treated prior to infiltration to protect groundwater quality.
- Not suitable on fill sites or steep slopes.
- Risk of groundwater contamination in very coarse soils.
- Upstream drainage area must be completely stabilized before construction.
- Difficult to restore functioning of infiltration basins once clogged.

Design and Sizing Guidelines

- Water quality volume determined by local requirements or sized so that 85% of the annual runoff volume is captured.
- Basin sized so that the entire water quality volume is infiltrated within 48 hours.
- Vegetation establishment on the basin floor may help reduce the clogging rate.

Construction/Inspection Considerations

- Before construction begins, stabilize the entire area draining to the facility. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction or remove the top 2 inches of soil after the site is stabililized. Stabilize the entire contributing drainage area, including the side slopes, before allowing any runoff to enter once construction is complete.
- Place excavated material such that it can not be washed back into the basin if a storm occurs during construction of the facility.
- Build the basin without driving heavy equipment over the infiltration surface. Any equipment driven on the surface should have extra-wide ("low pressure") tires. Prior to any construction, rope off the infiltration area to stop entrance by unwanted equipment.
- After final grading, till the infiltration surface deeply.
- Use appropriate erosion control seed mix for the specific project and location.

Performance

As water migrates through porous soil and rock, pollutant attenuation mechanisms include precipitation, sorption, physical filtration, and bacterial degradation. If functioning properly, this approach is presumed to have high removal efficiencies for particulate pollutants and moderate removal of soluble pollutants. Actual pollutant removal in the subsurface would be expected to vary depending upon site-specific soil types. This technology eliminates discharge to surface waters except for the very largest storms; consequently, complete removal of all stormwater constituents can be assumed.

There remain some concerns about the potential for groundwater contamination despite the findings of the NURP and Nightingale (1975; 1987a,b,c; 1989). For instance, a report by Pitt et al. (1994) highlighted the potential for groundwater contamination from intentional and unintentional stormwater infiltration. That report recommends that infiltration facilities not be sited in areas where high concentrations are present or where there is a potential for spills of toxic material. Conversely, Schroeder (1995) reported that there was no evidence of groundwater impacts from an infiltration basin serving a large industrial catchment in Fresno, CA.

Siting Criteria

The key element in siting infiltration basins is identifying sites with appropriate soil and hydrogeologic properties, which is critical for long term performance. In one study conducted in Prince George's County, Maryland (Galli, 1992), all of the infiltration basins investigated clogged within 2 years. It is believed that these failures were for the most part due to allowing infiltration at sites with rates of less than 0.5 in/hr, basing siting on soil type rather than field infiltration tests, and poor construction practices that resulted in soil compaction of the basin invert.

A study of 23 infiltration basins in the Pacific Northwest showed better long-term performance in an area with highly permeable soils (Hilding, 1996). In this study, few of the infiltration basins had failed after 10 years. Consequently, the following guidelines for identifying appropriate soil and subsurface conditions should be rigorously adhered to.

- Determine soil type (consider RCS soil type 'A, B or C' only) from mapping and consult USDA soil survey tables to review other parameters such as the amount of silt and clay, presence of a restrictive layer or seasonal high water table, and estimated permeability. The soil should not have more than 30% clay or more than 40% of clay and silt combined. Eliminate sites that are clearly unsuitable for infiltration.

- Groundwater separation should be at least 3 m from the basin invert to the measured ground water elevation. There is concern at the state and regional levels of the impact on groundwater quality from infiltrated runoff, especially when the separation between groundwater and the surface is small.

- Location away from buildings, slopes and highway pavement (greater than 6 m) and wells and bridge structures (greater than 30 m). Sites constructed of fill, having a base flow or with a slope greater than 15% should not be considered.

- Ensure that adequate head is available to operate flow splitter structures (to allow the basin to be offline) without ponding in the splitter structure or creating backwater upstream of the splitter.

- Base flow should not be present in the tributary watershed.

Secondary Screening Based on Site Geotechnical Investigation

- At least three in-hole conductivity tests shall be performed using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring), two tests at different locations within the proposed basin and the third down gradient by no more than approximately 10 m. The tests shall measure permeability in the side slopes and the bed within a depth of 3 m of the invert.

- The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 13 mm/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.

- Exclude from consideration sites constructed in fill or partially in fill unless no silts or clays are present in the soil boring. Fill tends to be compacted, with clays in a dispersed rather than flocculated state, greatly reducing permeability.

- The geotechnical investigation should be such that a good understanding is gained as to how the stormwater runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

Additional Design Guidelines

(1) Basin Sizing - The required water quality volume is determined by local regulations or sufficient to capture 85% of the annual runoff.

(2) Provide pretreatment if sediment loading is a maintenance concern for the basin.

(3) Include energy dissipation in the inlet design for the basins. Avoid designs that include a permanent pool to reduce opportunity for standing water and associated vector problems.

(4) Basin invert area should be determined by the equation:

$$A = \frac{WQV}{kt}$$

where A = Basin invert area (m^2)

WQV = water quality volume (m^3)

k = 0.5 times the lowest field-measured hydraulic conductivity (m/hr)

t = drawdown time (48 hr)

(5) The use of vertical piping, either for distribution or infiltration enhancement shall not be allowed to avoid device classification as a Class V injection well per 40 CFR146.5(e)(4).

Maintenance

Regular maintenance is critical to the successful operation of infiltration basins. Recommended operation and maintenance guidelines include:

- Inspections and maintenance to ensure that water infiltrates into the subsurface completely (recommended infiltration rate of 72 hours or less) and that vegetation is carefully managed to prevent creating mosquito and other vector habitats.
- Observe drain time for the design storm after completion or modification of the facility to confirm that the desired drain time has been obtained.
- Schedule semiannual inspections for beginning and end of the wet season to identify potential problems such as erosion of the basin side slopes and invert, standing water, trash and debris, and sediment accumulation.
- Remove accumulated trash and debris in the basin at the start and end of the wet season.
- Inspect for standing water at the end of the wet season.
- Trim vegetation at the beginning and end of the wet season to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and regrade when the accumulated sediment volume exceeds 10% of the basin.
- If erosion is occurring within the basin, revegetate immediately and stabilize with an erosion control mulch or mat until vegetation cover is established.
- To avoid reversing soil development, scarification or other disturbance should only be performed when there are actual signs of clogging, rather than on a routine basis. Always remove deposited sediments before scarification, and use a hand-guided rotary tiller, if possible, or a disc harrow pulled by a very light tractor.

Cost

Infiltration basins are relatively cost-effective practices because little infrastructure is needed when constructing them. One study estimated the total construction cost at about $2 per ft (adjusted for inflation) of storage for a 0.25-acre basin (SWRPC, 1991). As with other BMPs, these published cost estimates may deviate greatly from what might be incurred at a specific site. For instance, Caltrans spent about $18/ft^3 for the two infiltration basins constructed in southern California, each of which had a water quality volume of about 0.34 ac.-ft. Much of the higher cost can be attributed to changes in the storm drain system necessary to route the runoff to the basin locations.

Infiltration basins typically consume about 2 to 3% of the site draining to them, which is relatively small. Additional space may be required for buffer, landscaping, access road, and fencing. Maintenance costs are estimated at 5 to 10% of construction costs.

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly maintained, infiltration basins have a high failure rate. Thus, it may be necessary to replace the basin with a different technology after a relatively short period of time.

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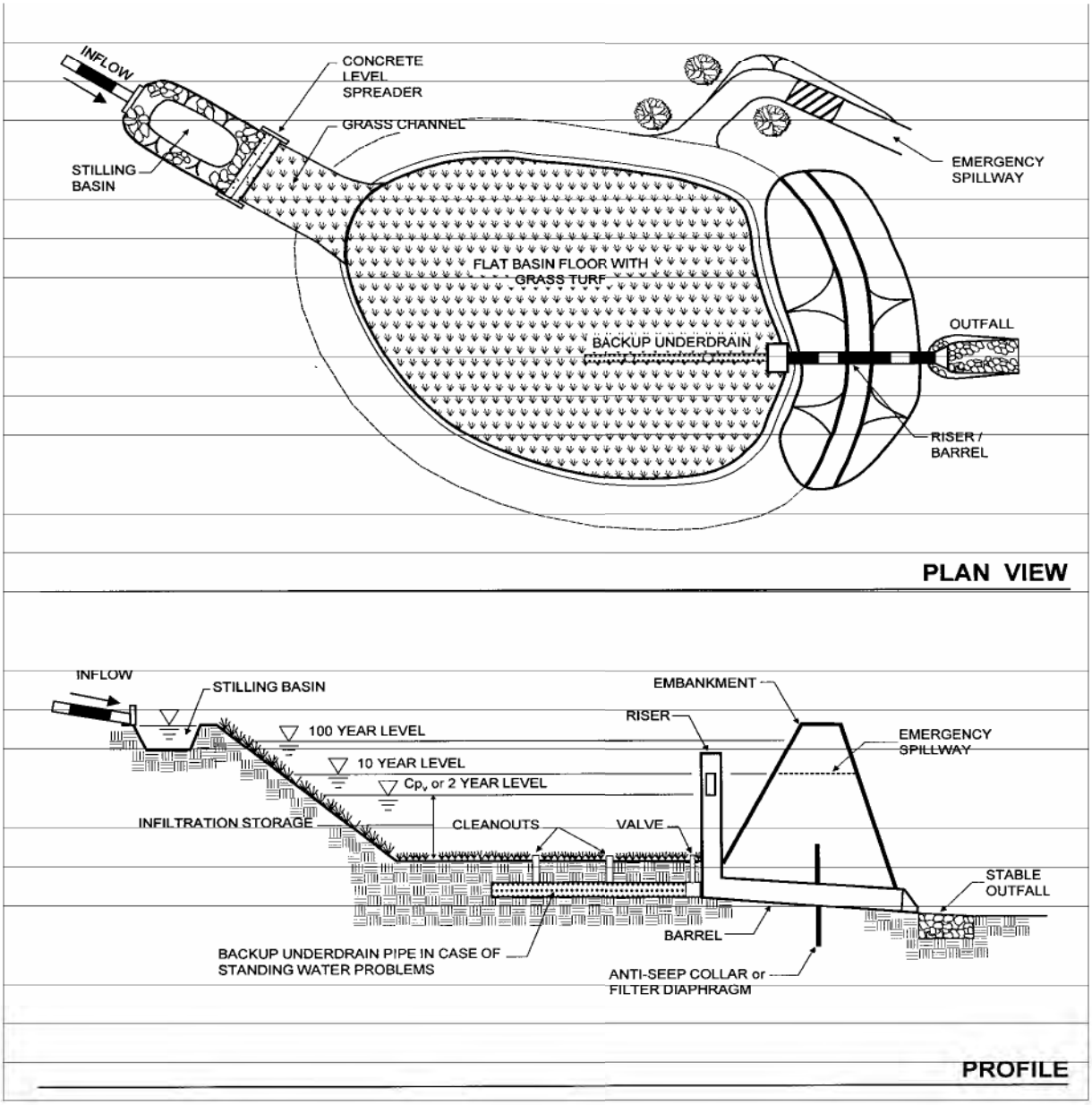
INFLOW
CONCRETE LEVEL SPREADER
GRASS CHANNEL
STILLING BASIN
EMERGENCY SPILLWAY
FLAT BASIN FLOOR WITH GRASS TURF
OUTFALL
BACKUP UNDERDRAIN
RISER / BARREL
PLAN VIEW
INFLOW
STILLING BASIN
EMBANKMENT
RISER
100 YEAR LEVEL
EMERGENCY SPILLWAY
10 YEAR LEVEL
Cp_v or 2 YEAR LEVEL
INFILTRATION STORAGE
CLEANOUTS
VALVE
STABLE OUTFALL
BARREL
BACKUP UNDERDRAIN PIPE IN CASE OF STANDING WATER PROBLEMS
ANTI-SEEP COLLAR or FILTER DIAPHRAGM
PROFILE

Extended Detention Basin TC-22

Design Considerations

- Tributary Area
- Area Required
- Hydraulic Head

Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	■
☑	Metals	▲
☑	Bacteria	▲
☑	Oil and Grease	▲
☑	Organics	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

California Experience

Caltrans constructed and monitored 5 extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration that occurred, than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. The small headloss and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment.

Advantages

- Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.
- Extended detention basins can provide substantial capture of sediment and the toxics fraction associated with particulates.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency

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relationships resulting from the increase of impervious cover in a watershed.

Limitations

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).
- Dry extended detention ponds have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.
- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home due to the adverse aesthetics of dry, bare areas and inlet and outlet structures.

Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.
- Outlet designed to discharge the capture volume over a period of hours.
- Length to width ratio of at least 1.5:1 where feasible.
- Basin depths optimally range from 2 to 5 feet.
- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.
- A maintenance ramp and perimeter access should be included in the design to facilitate access to the basin for maintenance activities and for vector surveillance and control.
- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be determined to downstream fisheries.

Construction/Inspection Considerations

- Inspect facility after first large to storm to determine whether the desired residence time has been achieved.
- When constructed with small tributary area, orifice sizing is critical and inspection should verify that flow through additional openings such as bolt holes does not occur.

Performance

One objective of stormwater management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most detention ponds.

Dry extended detention basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Several studies are available on the effectiveness of dry extended detention ponds including one recently concluded by Caltrans (2002).

The load reduction is greater than the concentration reduction because of the substantial infiltration that occurs. Although the infiltration of stormwater is clearly beneficial to surface receiving waters, there is the potential for groundwater contamination. Previous research on the effects of incidental infiltration on groundwater quality indicated that the risk of contamination is minimal.

There were substantial differences in the amount of infiltration that were observed in the earthen basins during the Caltrans study. On average, approximately 40 percent of the runoff entering the unlined basins infiltrated and was not discharged. The percentage ranged from a high of about 60 percent to a low of only about 8 percent for the different facilities. Climatic conditions and local water table elevation are likely the principal causes of this difference. The least infiltration occurred at a site located on the coast where humidity is higher and the basin invert is within a few meters of sea level. Conversely, the most infiltration occurred at a facility located well inland in Los Angeles County where the climate is much warmer and the humidity is less, resulting in lower soil moisture content in the basin floor at the beginning of storms.

Vegetated detention basins appear to have greater pollutant removal than concrete basins. In the Caltrans study, the concrete basin exported sediment and associated pollutants during a number of storms. Export was not as common in the earthen basins, where the vegetation appeared to help stabilize the retained sediment.

Siting Criteria

Dry extended detention ponds are among the most widely applicable stormwater management practices and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. In addition, many communities have detention basins designed for flood control. It is possible to modify these facilities to incorporate features that provide water quality treatment and/or channel protection. Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

In general, dry extended detention ponds should be used on sites with a minimum area of 5 acres. With this size catchment area, the orifice size can be on the order of 0.5 inches. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale.

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds may need an impermeable liner to prevent ground water contamination.

The base of the extended detention facility should not intersect the water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

A study in Prince George's County, Maryland, found that stormwater management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain stormwater for a relatively short time (i.e., 24 hours) to minimize the amount of warming that occurs in the basin.

Additional Design Guidelines

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be sized appropriately. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the design of the basin should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al., 1996).

Energy dissipation structures should be included for the basin inlet to prevent resuspension of accumulated sediment. The use of stilling basins for this purpose should be avoided because the standing water provides a breeding area for mosquitoes.

Extended detention facilities should be sized to completely capture the water quality volume. A micropool is often recommended for inclusion in the design and one is shown in the schematic diagram. These small permanent pools greatly increase the potential for mosquito breeding and complicate maintenance activities; consequently, they are not recommended for use in California.

A large aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W) where feasible. Basin depths optimally range from 2 to 5 feet.

The facility's drawdown time should be regulated by an orifice or weir. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The outlet design implemented by Caltrans in the facilities constructed in San Diego County used an outlet riser with orifices

Figure 1
Example of Extended Detention Outlet Structure

sized to discharge the water quality volume, and the riser overflow height was set to the design storm elevation. A stainless steel screen was placed around the outlet riser to ensure that the orifices would not become clogged with debris. Sites either used a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. A picture of a typical outlet is presented in Figure 1.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure can be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed.

Summary of Design Recommendations

(1) Facility Sizing - The required water quality volume is determined by local regulations or the basin should be sized to capture and treat 85% of the annual runoff volume. See Section 5.5.1 of the handbook for a discussion of volume-based design.

Basin Configuration – A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flowpath length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from 100-year storm.

(2) Pond Side Slopes - Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.

(3) Basin Lining – Basins must be constructed to prevent possible contamination of groundwater below the facility.

(4) Basin Inlet – Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting.

(5) Outflow Structure - The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

$$Q = CA(2g(H-H_o))^{0.5}$$

where: Q = discharge (ft^3/s)
C = orifice coefficient
A = area of the orifice (ft^2)
g = gravitational constant (32.2)
H = water surface elevation (ft)
H_o= orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the pond stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to H_o. When using multiple orifices the discharge from each is summed.

(6) Splitter Box - When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year storm event while providing at least 1.0 foot of freeboard along pond side slopes.

(7) Erosion Protection at the Outfall - For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.

(8) Safety Considerations - Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

Maintenance

Routine maintenance activity is often thought to consist mostly of sediment and trash and debris removal; however, these activities often constitute only a small fraction of the maintenance hours. During a recent study by Caltrans, 72 hours of maintenance was performed annually, but only a little over 7 hours was spent on sediment and trash removal. The largest recurring activity was vegetation management, routine mowing. The largest absolute number of hours was associated with vector control because of mosquito breeding that occurred in the stilling basins (example of standing water to be avoided) installed as energy dissipaters. In most cases, basic housekeeping practices such as removal of debris accumulations and vegetation

management to ensure that the basin dewaters completely in 48-72 hours is sufficient to prevent creating mosquito and other vector habitats.

Consequently, maintenance costs should be estimated based primarily on the mowing frequency and the time required. Mowing should be done at least annually to avoid establishment of woody vegetation, but may need to be performed much more frequently if aesthetics are an important consideration.

Typical activities and frequencies include:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, slope stability, sediment accumulation, trash and debris, and presence of burrows.
- Remove accumulated trash and debris in the basin and around the riser pipe during the semiannual inspections. The frequency of this activity may be altered to meet specific site conditions.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and re-grade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Inspect the basin each year for accumulated sediment volume.

Cost

Construction Cost

The construction costs associated with extended detention basins vary considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation:

$$C = 12.4V^{0.760}$$

where: C = Construction, design, and permitting cost, and
V = Volume (ft^3).

Using this equation, typical construction costs are:

$ 41,600 for a 1 acre-foot pond

$ 239,000 for a 10 acre-foot pond

$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the predicted cost of wet ponds (according to Brown and Schueler, 1997) on a cost per total volume basis, which highlights the difficulty of developing reasonably accurate construction estimates. In addition, a typical facility constructed by Caltrans cost about $160,000 with a capture volume of only 0.3 ac-ft.

An economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the

perceived value of homes adjacent to a dry pond by between 3 and 10 percent (Emmerling-Dinovo, 1995).

Maintenance Cost

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost (EPA website). Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Table 1 presents the maintenance costs estimated by Caltrans based on their experience with five basins located in southern California. Again, it should be emphasized that the vast majority of hours are related to vegetation management (mowing).

Table 1 Estimated Average Annual Maintenance Effort

Activity	Labor Hours	Equipment & Material ($)	Cost
Inspections	4	7	183
Maintenance	49	126	2282
Vector Control	0	0	0
Administration	3	0	132
Materials	-	535	535
Total	**56**	**$668**	**$3,132**

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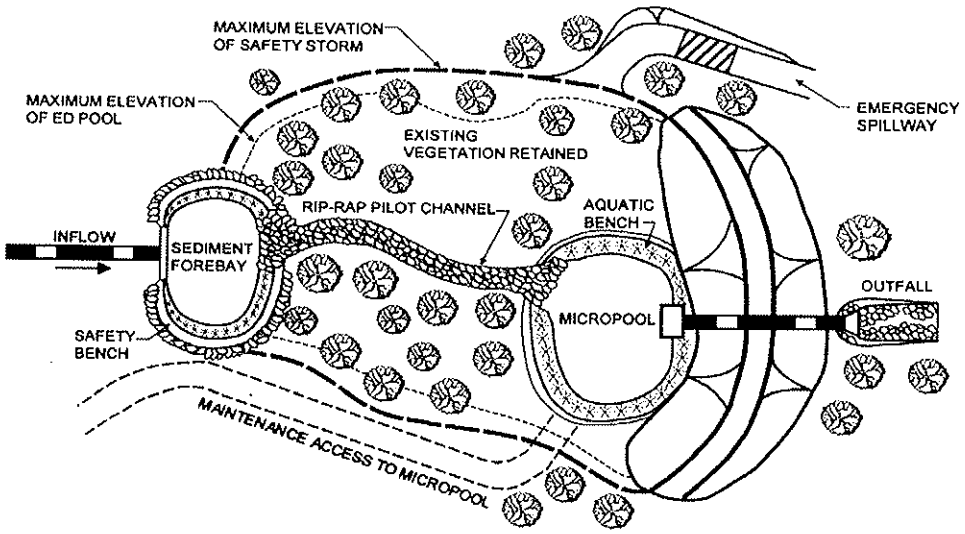
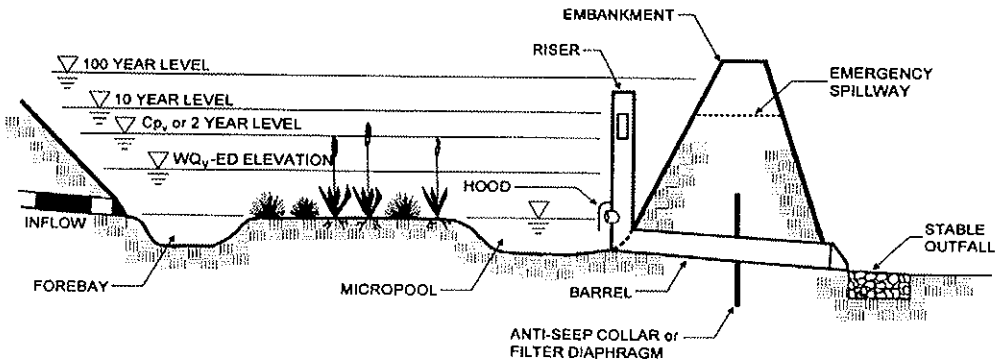


PLAN VIEW



PROFILE

Schematic of an Extended Detention Basin (MDE, 2000)

Vegetated Swale TC-30

Design Considerations

- Tributary Area
- Area Required
- Slope
- Water Availability

Description

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	●
☑	Metals	▲
☑	Bacteria	●
☑	Oil and Grease	▲
☑	Organics	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

California Experience

Caltrans constructed and monitored six vegetated swales in southern California. These swales were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- If properly designed, vegetated, and operated, swales can serve as an aesthetic, potentially inexpensive urban development or roadway drainage conveyance measure with significant collateral water quality benefits.

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- Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible.

Limitations

- Can be difficult to avoid channelization.
- May not be appropriate for industrial sites or locations where spills may occur
- Grassed swales cannot treat a very large drainage area. Large areas may be divided and treated using multiple swales.
- A thick vegetative cover is needed for these practices to function properly.
- They are impractical in areas with steep topography.
- They are not effective and may even erode when flow velocities are high, if the grass cover is not properly maintained.
- In some places, their use is restricted by law: many local municipalities require curb and gutter systems in residential areas.
- Swales are mores susceptible to failure if not properly maintained than other treatment BMPs.

Design and Sizing Guidelines

- Flow rate based design determined by local requirements or sized so that 85% of the annual runoff volume is discharged at less than the design rainfall intensity.
- Swale should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, which ever is less, at the design treatment rate.
- Longitudinal slopes should not exceed 2.5%
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing, plants that thrive under the specific site, climatic, and watering conditions should be specified. Vegetation whose growing season corresponds to the wet season are preferred. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.
- The width of the swale should be determined using Manning's Equation using a value of 0.25 for Manning's n.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.
- Install swales at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be used.
- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the swale or strip.
- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.
- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height.

Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients.

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

Only 9 studies have been conducted on all grassed channels designed for water quality (Table 1). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorus.

Table 1 Grassed swale pollutant removal efficiency data							
	Removal Efficiencies (% Removal)						
Study	TSS	TP	TN	NO_3	Metals	Bacteria	Type
Caltrans 2002	77	8	67	66	83-90	-33	dry swales
Goldberg 1993	67.8	4.5	-	31.4	42–62	-100	grassed channel
Seattle Metro and Washington Department of Ecology 1992	60	45	-	-25	2–16	-25	grassed channel
Seattle Metro and Washington Department of Ecology, 1992	83	29	-	-25	46–73	-25	grassed channel
Wang et al., 1981	80	-	-	-	70–80	-	dry swale
Dorman et al., 1989	98	18	-	45	37–81	-	dry swale
Harper, 1988	87	83	84	80	88–90	-	dry swale
Kercher et al., 1983	99	99	99	99	99	-	dry swale
Harper, 1988.	81	17	40	52	37–69	-	wet swale
Koon, 1995	67	39	-	9	-35 to 6	-	wet swale

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although some swales appear to export soluble phosphorus (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils.

Siting Criteria

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system (Schueler et al., 1992). In general, swales can be used to serve areas of less than 10 acres, with slopes no greater than 5 %. Use of natural topographic lows is encouraged and natural drainage courses should be regarded as significant local resources to be kept in use (Young et al., 1996).

Selection Criteria (NCTCOG, 1993)

- Comparable performance to wet basins
- Limited to treating a few acres
- Availability of water during dry periods to maintain vegetation
- Sufficient available land area

Research in the Austin area indicates that vegetated controls are effective at removing pollutants even when dormant. Therefore, irrigation is not required to maintain growth during dry periods, but may be necessary only to prevent the vegetation from dying.

The topography of the site should permit the design of a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

Additional Design Guidelines

Most of the design guidelines adopted for swale design specify a minimum hydraulic residence time of 9 minutes. This criterion is based on the results of a single study conducted in Seattle, Washington (Seattle Metro and Washington Department of Ecology, 1992), and is not well supported. Analysis of the data collected in that study indicates that pollutant removal at a residence time of 5 minutes was not significantly different, although there is more variability in that data. Therefore, additional research in the design criteria for swales is needed. Substantial pollutant removal has also been observed for vegetated controls designed solely for conveyance (Barrett et al, 1998); consequently, some flexibility in the design is warranted.

Many design guidelines recommend that grass be frequently mowed to maintain dense coverage near the ground surface. Recent research (Colwell et al., 2000) has shown mowing frequency or grass height has little or no effect on pollutant removal.

Summary of Design Recommendations

1) The swale should have a length that provides a minimum hydraulic residence time of at least 10 minutes. The maximum bottom width should not exceed 10 feet unless a dividing berm is provided. The depth of flow should not exceed 2/3rds the height of the grass at the peak of the water quality design storm intensity. The channel slope should not exceed 2.5%.

2) A design grass height of 6 inches is recommended.

3) Regardless of the recommended detention time, the swale should be not less than 100 feet in length.

4) The width of the swale should be determined using Manning's Equation, at the peak of the design storm, using a Manning's n of 0.25.

5) The swale can be sized as both a treatment facility for the design storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line." The side slopes should be no steeper than 3:1 (H:V).

6) Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible. If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.

7) Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation

establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover.

Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are summarized below:

- Inspect swales at least twice annually for erosion, damage to vegetation, and sediment and debris accumulation preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the swale is ready for winter. However, additional inspection after periods of heavy runoff is desirable. The swale should be checked for debris and litter, and areas of sediment accumulation.
- Grass height and mowing frequency may not have a large impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.
- Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to mowing.
- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 mm (3 in.) at any spot, or covers vegetation.
- Regularly inspect swales for pools of standing water. Swales can become a nuisance due to mosquito breeding in standing water if obstructions develop (e.g. debris accumulation, invasive vegetation) and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately $0.25 per ft^2. This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most stormwater management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately $0.50 per ft^2, which compares favorably with other stormwater management practices.

Table 2 Swale Cost Estimate (SEWRPC, 1991)

Component	Unit	Extent	Unit Cost			Total Cost		
			Low	Moderate	High	Low	Moderate	High
Mobilization / Demobilization-Light	Swale	1	$107	$274	$441	$107	$274	$441
Site Preparation								
Clearing[b]	Acre	0.5	$2,200	$3,800	$5,400	$1,100	$1,900	$2,700
Grubbing[c]	Acre	0.25	$3,800	$5,200	$6,600	$950	$1,300	$1,650
General Excavation[d]	Yd^3	372	$2.10	$3.70	$5.30	$781	$1,376	$1,972
Level and Till[e]	Yd^2	1,210	$0.20	$0.35	$0.50	$242	$424	$605
Sites Development								
Salvaged Topsoil Seed, and Mulch[f]	Yd^2	1,210	$0.40	$1.00	$1.60	$484	$1,210	$1,936
Sod[g]	Yd^2	1,210	$1.20	$2.40	$3.60	$1,452	$2,904	$4,356
Subtotal	--	--	--	--	--	$5,116	$9,388	$13,660
Contingencies	Swale	1	25%	25%	25%	$1,279	$2,347	$3,415
Total	--	--	--	--	--	$6,395	$11,735	$17,075

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[a] Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

[b] Area cleared = (top width + 10 feet) x swale length.

[c] Area grubbed = (top width x swale length).

[d] Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

[e] Area tilled = $\left(\text{top width} + \frac{8(\text{swale depth}^2)}{3(\text{top width})}\right) \times$ swale length (parabolic cross-section).

[f] Area seeded = area cleared x 0.5.

[g] Area sodded = area cleared x 0.5.

Table 3 Estimated Maintenance Costs (SEWRPC, 1991)

Component	Unit Cost	Swale Size (Depth and Top Width)		Comment
		1.5 Foot Depth, One-Foot Bottom Width, 10-Foot Top Width	3-Foot Depth, 3-Foot Bottom Width, 21-Foot Top Width	
Lawn Mowing	\$0.85 / 1,000 ft^2 / mowing	\$0.14 / linear foot	\$0.21 / linear foot	Lawn maintenance area=(top width + 10 feet) x length. Mow eight times per year
General Lawn Care	\$9.00 / 1,000 ft^2 / year	\$0.18 / linear foot	\$0.28 / linear foot	Lawn maintenance area = (top width + 10 feet) x length
Swale Debris and Litter Removal	\$0.10 / linear foot / year	\$0.10 / linear foot	\$0.10 / linear foot	–
Grass Reseeding with Mulch and Fertilizer	\$0.30 / yd^2	\$0.01 / linear foot	\$0.01 / linear foot	Area revegetated equals 1% of lawn maintenance area per year
Program Administration and Swale Inspection	\$0.15 / linear foot / year, plus \$25 / inspection	\$0.15 / linear foot	\$0.15 / linear foot	Inspect four times per year
Total	--	**\$0.58 / linear foot**	**\$ 0.75 / linear foot**	–

Maintenance Cost

Caltrans (2002) estimated the expected annual maintenance cost for a swale with a tributary area of approximately 2 ha at approximately $2,700. Since almost all maintenance consists of mowing, the cost is fundamentally a function of the mowing frequency. Unit costs developed by SEWRPC are shown in Table 3. In many cases vegetated channels would be used to convey runoff and would require periodic mowing as well, so there may be little additional cost for the water quality component. Since essentially all the activities are related to vegetation management, no special training is required for maintenance personnel.

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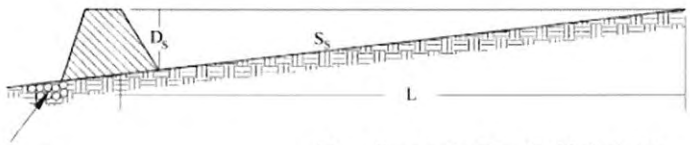
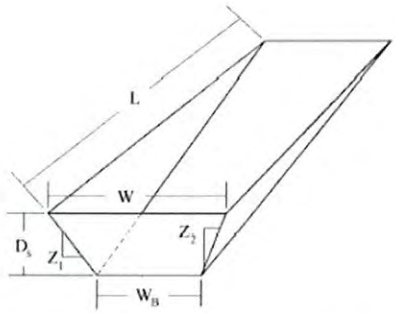


Provide for scour protection.

(a) Cross section of swale with check dam.



(b) Dimensional view of swale impoundment area.

Notation:

L = Length of swale impoundment area per check dam (ft)
D_S = Depth of check dam (ft)
S_S = Bottom slpe of swale (ft/ft)
W = Top width of check dam (ft)
W_B = Bottom width of check dam (ft)
$Z_{1&2}$ = Ratio of horizontal to vertical change in swale side slope (ft/ft)

Bioretention TC-32

Design Considerations

- Soil for Infiltration
- Tributary Area
- Slope
- Aesthetics
- Environmental Side-effects

Description

The bioretention best management practice (BMP) functions as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through buffer strip and subsequently distributed evenly along a ponding area. Exfiltration of the stored water in the bioretention area planting soil into the underlying soils occurs over a period of days.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	▲
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

California Experience

None documented. Bioretention has been used as a stormwater BMP since 1992. In addition to Prince George's County, MD and Alexandria, VA, bioretention has been used successfully at urban and suburban areas in Montgomery County, MD; Baltimore County, MD; Chesterfield County, VA; Prince William County, VA; Smith Mountain Lake State Park, VA; and Cary, NC.

Advantages

- Bioretention provides stormwater treatment that enhances the quality of downstream water bodies by temporarily storing runoff in the BMP and releasing it over a period of four days to the receiving water (EPA, 1999).
- The vegetation provides shade and wind breaks, absorbs noise, and improves an area's landscape.

Limitations

- The bioretention BMP is not recommended for areas with slopes greater than 20% or where mature tree removal would

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be required since clogging may result, particularly if the BMP receives runoff with high sediment loads (EPA, 1999).

- Bioretention is not a suitable BMP at locations where the water table is within 6 feet of the ground surface and where the surrounding soil stratum is unstable.
- By design, bioretention BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water.
- In cold climates the soil may freeze, preventing runoff from infiltrating into the planting soil.

Design and Sizing Guidelines

- The bioretention area should be sized to capture the design storm runoff.
- In areas where the native soil permeability is less than 0.5 in/hr an underdrain should be provided.
- Recommended minimum dimensions are 15 feet by 40 feet, although the preferred width is 25 feet. Excavated depth should be 4 feet.
- Area should drain completely within 72 hours.
- Approximately 1 tree or shrub per 50 ft^2 of bioretention area should be included.
- Cover area with about 3 inches of mulch.

Construction/Inspection Considerations

Bioretention area should not be established until contributing watershed is stabilized.

Performance

Bioretention removes stormwater pollutants through physical and biological processes, including adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization (EPA, 1999). Adsorption is the process whereby particulate pollutants attach to soil (e.g., clay) or vegetation surfaces. Adequate contact time between the surface and pollutant must be provided for in the design of the system for this removal process to occur. Thus, the infiltration rate of the soils must not exceed those specified in the design criteria or pollutant removal may decrease. Pollutants removed by adsorption include metals, phosphorus, and hydrocarbons. Filtration occurs as runoff passes through the bioretention area media, such as the sand bed, ground cover, and planting soil.

Common particulates removed from stormwater include particulate organic matter, phosphorus, and suspended solids. Biological processes that occur in wetlands result in pollutant uptake by plants and microorganisms in the soil. Plant growth is sustained by the uptake of nutrients from the soils, with woody plants locking up these nutrients through the seasons. Microbial activity within the soil also contributes to the removal of nitrogen and organic matter. Nitrogen is removed by nitrifying and denitrifying bacteria, while aerobic bacteria are responsible for the decomposition of the organic matter. Microbial processes require oxygen and can result in depleted oxygen levels if the bioretention area is not adequately

aerated. Sedimentation occurs in the swale or ponding area as the velocity slows and solids fall out of suspension.

The removal effectiveness of bioretention has been studied during field and laboratory studies conducted by the University of Maryland (Davis et al, 1998). During these experiments, synthetic stormwater runoff was pumped through several laboratory and field bioretention areas to simulate typical storm events in Prince George's County, MD. Removal rates for heavy metals and nutrients are shown in Table 1.

Table 1 Laboratory and Estimated Bioretention Davis et al. (1998); PGDER (1993)

Pollutant	Removal Rate
Total Phosphorus	70-83%
Metals (Cu, Zn, Pb)	93-98%
TKN	68-80%
Total Suspended Solids	90%
Organics	90%
Bacteria	90%

Results for both the laboratory and field experiments were similar for each of the pollutants analyzed. Doubling or halving the influent pollutant levels had little effect on the effluent pollutants concentrations (Davis et al, 1998).

The microbial activity and plant uptake occurring in the bioretention area will likely result in higher removal rates than those determined for infiltration BMPs.

Siting Criteria

Bioretention BMPs are generally used to treat stormwater from impervious surfaces at commercial, residential, and industrial areas (EPA, 1999). Implementation of bioretention for stormwater management is ideal for median strips, parking lot islands, and swales. Moreover, the runoff in these areas can be designed to either divert directly into the bioretention area or convey into the bioretention area by a curb and gutter collection system.

The best location for bioretention areas is upland from inlets that receive sheet flow from graded areas and at areas that will be excavated (EPA, 1999). In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosive conditions as sheet flow is conveyed to the treatment area. Locations where a bioretention area can be readily incorporated into the site plan without further environmental damage are preferred. Furthermore, to effectively minimize sediment loading in the treatment area, bioretention only should be used in stabilized drainage areas.

Additional Design Guidelines

The layout of the bioretention area is determined after site constraints such as location of utilities, underlying soils, existing vegetation, and drainage are considered (EPA, 1999). Sites with loamy sand soils are especially appropriate for bioretention because the excavated soil can be backfilled and used as the planting soil, thus eliminating the cost of importing planting soil.

The use of bioretention may not be feasible given an unstable surrounding soil stratum, soils with clay content greater than 25 percent, a site with slopes greater than 20 percent, and/or a site with mature trees that would be removed during construction of the BMP.

Bioretention can be designed to be off-line or on-line of the existing drainage system (EPA, 1999). The drainage area for a bioretention area should be between 0.1 and 0.4 hectares (0.25 and 1.0 acres). Larger drainage areas may require multiple bioretention areas. Furthermore, the maximum drainage area for a bioretention area is determined by the expected rainfall intensity and runoff rate. Stabilized areas may erode when velocities are greater than 5 feet per second (1.5 meter per second). The designer should determine the potential for erosive conditions at the site.

The size of the bioretention area, which is a function of the drainage area and the runoff generated from the area is sized to capture the water quality volume.

The recommended minimum dimensions of the bioretention area are 15 feet (4.6 meters) wide by 40 feet (12.2 meters) long, where the minimum width allows enough space for a dense, randomly-distributed area of trees and shrubs to become established. Thus replicating a natural forest and creating a microclimate, thereby enabling the bioretention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations which landscaped areas in urban settings typically are unable to tolerate. The preferred width is 25 feet (7.6 meters), with a length of twice the width. Essentially, any facilities wider than 20 feet (6.1 meters) should be twice as long as they are wide, which promotes the distribution of flow and decreases the chances of concentrated flow.

In order to provide adequate storage and prevent water from standing for excessive periods of time the ponding depth of the bioretention area should not exceed 6 inches (15 centimeters). Water should not be left to stand for more than 72 hours. A restriction on the type of plants that can be used may be necessary due to some plants' water intolerance. Furthermore, if water is left standing for longer than 72 hours mosquitoes and other insects may start to breed.

The appropriate planting soil should be backfilled into the excavated bioretention area. Planting soils should be sandy loam, loamy sand, or loam texture with a clay content ranging from 10 to 25 percent.

Generally the soil should have infiltration rates greater than 0.5 inches (1.25 centimeters) per hour, which is typical of sandy loams, loamy sands, or loams. The pH of the soil should range between 5.5 and 6.5, where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. Additional requirements for the planting soil include a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts.

Soil tests should be performed for every 500 cubic yards (382 cubic meters) of planting soil, with the exception of pH and organic content tests, which are required only once per bioretention area (EPA, 1999). Planting soil should be 4 inches (10.1 centimeters) deeper than the bottom of the largest root ball and 4 feet (1.2 meters) altogether. This depth will provide adequate soil for the plants' root systems to become established, prevent plant damage due to severe wind, and provide adequate moisture capacity. Most sites will require excavation in order to obtain the recommended depth.

Planting soil depths of greater than 4 feet (1.2 meters) may require additional construction practices such as shoring measures (EPA, 1999). Planting soil should be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached. Since high canopy trees may be destroyed during maintenance the bioretention area should be vegetated to resemble a terrestrial forest community ecosystem that is dominated by understory trees. Three species each of both trees and shrubs are recommended to be planted at a rate of 2500 trees and shrubs per hectare (1000 per acre). For instance, a 15 foot (4.6 meter) by 40 foot (12.2 meter) bioretention area (600 square feet or 55.75 square meters) would require 14 trees and shrubs. The shrub-to-tree ratio should be 2:1 to 3:1.

Trees and shrubs should be planted when conditions are favorable. Vegetation should be watered at the end of each day for fourteen days following its planting. Plant species tolerant of pollutant loads and varying wet and dry conditions should be used in the bioretention area.

The designer should assess aesthetics, site layout, and maintenance requirements when selecting plant species. Adjacent non-native invasive species should be identified and the designer should take measures, such as providing a soil breach to eliminate the threat of these species invading the bioretention area. Regional landscaping manuals should be consulted to ensure that the planting of the bioretention area meets the landscaping requirements established by the local authorities. The designers should evaluate the best placement of vegetation within the bioretention area. Plants should be placed at irregular intervals to replicate a natural forest. Trees should be placed on the perimeter of the area to provide shade and shelter from the wind. Trees and shrubs can be sheltered from damaging flows if they are placed away from the path of the incoming runoff. In cold climates, species that are more tolerant to cold winds, such as evergreens, should be placed in windier areas of the site.

Following placement of the trees and shrubs, the ground cover and/or mulch should be established. Ground cover such as grasses or legumes can be planted at the beginning of the growing season. Mulch should be placed immediately after trees and shrubs are planted. Two to 3 inches (5 to 7.6 cm) of commercially-available fine shredded hardwood mulch or shredded hardwood chips should be applied to the bioretention area to protect from erosion.

Maintenance

The primary maintenance requirement for bioretention areas is that of inspection and repair or replacement of the treatment area's components. Generally, this involves nothing more than the routine periodic maintenance that is required of any landscaped area. Plants that are appropriate for the site, climatic, and watering conditions should be selected for use in the bioretention cell. Appropriately selected plants will aide in reducing fertilizer, pesticide, water, and overall maintenance requirements. Bioretention system components should blend over time through plant and root growth, organic decomposition, and the development of a natural

soil horizon. These biologic and physical processes over time will lengthen the facility's life span and reduce the need for extensive maintenance.

Routine maintenance should include a biannual health evaluation of the trees and shrubs and subsequent removal of any dead or diseased vegetation (EPA, 1999). Diseased vegetation should be treated as needed using preventative and low-toxic measures to the extent possible. BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water. Routine inspections for areas of standing water within the BMP and corrective measures to restore proper infiltration rates are necessary to prevent creating mosquito and other vector habitat. In addition, bioretention BMPs are susceptible to invasion by aggressive plant species such as cattails, which increase the chances of water standing and subsequent vector production if not routinely maintained.

In order to maintain the treatment area's appearance it may be necessary to prune and weed. Furthermore, mulch replacement is suggested when erosion is evident or when the site begins to look unattractive. Specifically, the entire area may require mulch replacement every two to three years, although spot mulching may be sufficient when there are random void areas. Mulch replacement should be done prior to the start of the wet season.

New Jersey's Department of Environmental Protection states in their bioretention systems standards that accumulated sediment and debris removal (especially at the inflow point) will normally be the primary maintenance function. Other potential tasks include replacement of dead vegetation, soil pH regulation, erosion repair at inflow points, mulch replenishment, unclogging the underdrain, and repairing overflow structures. There is also the possibility that the cation exchange capacity of the soils in the cell will be significantly reduced over time. Depending on pollutant loads, soils may need to be replaced within 5-10 years of construction (LID, 2000).

Cost

Construction Cost

Construction cost estimates for a bioretention area are slightly greater than those for the required landscaping for a new development (EPA, 1999). A general rule of thumb (Coffman, 1999) is that residential bioretention areas average about $3 to $4 per square foot, depending on soil conditions and the density and types of plants used. Commercial, industrial and institutional site costs can range between $10 to $40 per square foot, based on the need for control structures, curbing, storm drains and underdrains.

Retrofitting a site typically costs more, averaging $6,500 per bioretention area. The higher costs are attributed to the demolition of existing concrete, asphalt, and existing structures and the replacement of fill material with planting soil. The costs of retrofitting a commercial site in Maryland, Kettering Development, with 15 bioretention areas were estimated at $111,600.

In any bioretention area design, the cost of plants varies substantially and can account for a significant portion of the expenditures. While these cost estimates are slightly greater than those of typical landscaping treatment (due to the increased number of plantings, additional soil excavation, backfill material, use of underdrains etc.), those landscaping expenses that would be required regardless of the bioretention installation should be subtracted when determining the net cost.

Perhaps of most importance, however, the cost savings compared to the use of traditional structural stormwater conveyance systems makes bioretention areas quite attractive financially. For example, the use of bioretention can decrease the cost required for constructing stormwater conveyance systems at a site. A medical office building in Maryland was able to reduce the amount of storm drain pipe that was needed from 800 to 230 feet - a cost savings of $24,000 (PGDER, 1993). And a new residential development spent a total of approximately $100,000 using bioretention cells on each lot instead of nearly $400,000 for the traditional stormwater ponds that were originally planned (Rappahanock,). Also, in residential areas, stormwater management controls become a part of each property owner's landscape, reducing the public burden to maintain large centralized facilities.

Maintenance Cost

The operation and maintenance costs for a bioretention facility will be comparable to those of typical landscaping required for a site. Costs beyond the normal landscaping fees will include the cost for testing the soils and may include costs for a sand bed and planting soil.

References and Sources of Additional Information

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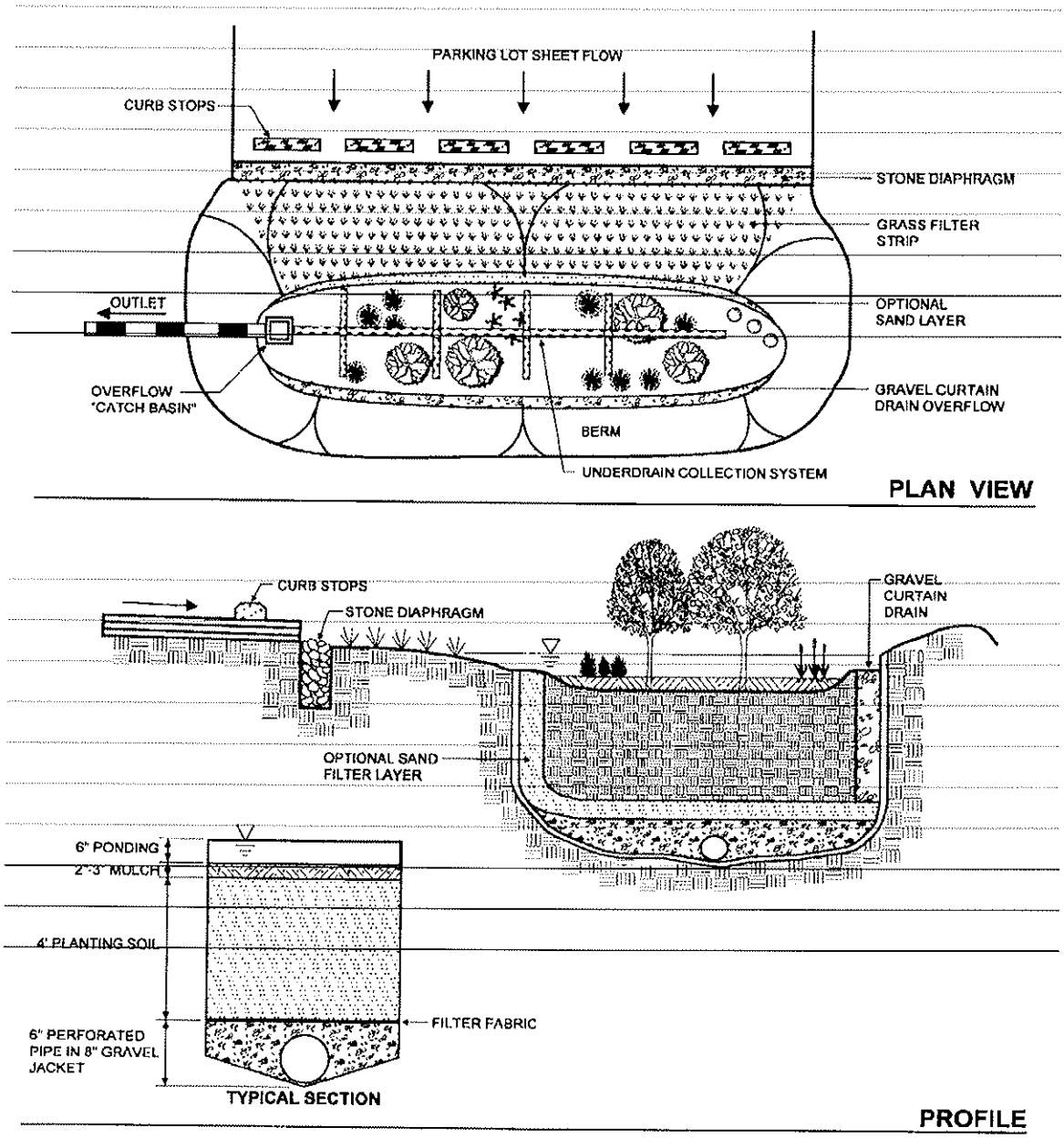

Schematic of a Bioretention Facility (MDE, 2000)

Appendix D
Stormwater Pollution Prevention Best Management Practices for Homeowner's Associations, Property Managers and Property Owners Manual

Stormwater Pollution Prevention

Best Management Practices for Homeowner's Associations, Property Managers and Property Owners

Your Guide To Maintaining Water Friendly Standards In Your Community

sbcountystormwater.org

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Redlands · Rialto · San Bernardino · San Bernardino County · San Bernardino County Flood Control District · Upland · Yucaipa

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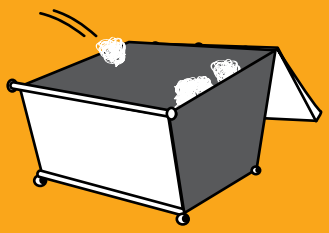
COMMERCIAL TRASH ENCLOSURES

FOLLOW THESE **REQUIREMENTS** TO **KEEP OUR WATERWAYS CLEAN**

Trash enclosures, such as those found in commercial and apartment complexes, typically contain materials that are intended to find their way to a landfill or a recycling facility. **These materials are NOT meant to go into our local lakes and rivers.**

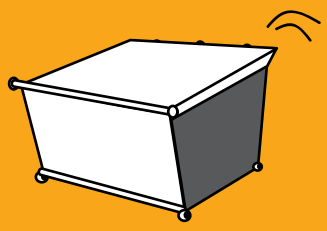
PROTECT WATER QUALITY BY FOLLOWING THESE SIMPLE STEPS

PUT TRASH INSIDE



Place trash inside the bin (preferably in sealed bags)

CLOSE THE LID



Prevent rain from entering the bin in order to avoid leakage of polluted water runoff

KEEP TOXICS OUT

- Paint
- Grease, fats and used oils
- Batteries, electronics and fluorescent lights

SOME ADDITIONAL GUIDELINES, INCLUDE

✓ SWEEP FREQUENTLY
Sweep trash enclosure areas frequently, instead of hosing them down, to prevent polluted water from flowing into the streets and storm drains.

✓ FIX LEAKS
Address trash bin leaks immediately by using dry clean up methods and report to your waste hauler to receive a replacement.

✓ CONSTRUCT ROOF
Construct a solid cover roof over the existing trash enclosure structure to prevent rainwater from coming into contact with trash and garbage. Check with your local City/County for Building Codes.

In San Bernardino County, stormwater pollution is caused by food waste, landscape waste, chemicals and other debris that are washed into storm drains and end up in our waterways - untreated! You can be part of the solution by maintaining a water-friendly trash enclosure.

THANK YOU FOR HELPING TO KEEP SAN BERNARDINO COUNTY CLEAN AND HEALTHY!

San Bernardino County STORMWATER PROGRAM

In the event of a spill or discharge to a storm drain or waterway, contact San Bernadino County Stormwater immediately: (877) WASTE18 | sbcountystormwater.org/report

sbcountystormwater.org

Big Bear • Chino • Chino Hills • Colton • Fontana • Grand Terrace • Highland • Loma Linda • Montclair • Ontario • Rancho Cucamongo
Redlands • Rialto • San Bernadino • San Bernadino County • San Bernadino County Flood Control District • Upland • Yucaipa

CESQG PROGRAM

Conditionally Exempt Small Quantity Generator

WHAT IS A CESQG?

Businesses that generate 27 gallons or 220 lbs. of hazardous waste, or 2.2 lbs. of extremely hazardous waste per month are called "Conditionally Exempt Small Quantity Generators," or CESQGs. San Bernardino County Household Hazardous Program provides waste management services to CESQG businesses. The most common CESQGs in San Bernardino County are painters, print shops, auto shops, builders, agricultural operators and property managers, but there are many others. When you call, be ready to describe the types and amounts of waste your business generates in a typical month. If you generate hazardous waste on a regular basis, you must:

- Register with San Bernardino County Fire Department (909) 386-8401 as a hazardous waste generator.
- To obtain an EPA ID# and application form from the State visit www.dtsc.ca.gov.
- Manage hazardous waste in accordance with all applicable local, state and federal laws and regulations.

HOW DO I GET SERVICE?

To arrange an appointment for the CESQG Program, call 1-800-OILY CAT or 909-382-5401. Be ready to describe the type and amount of hazardous waste your business is ready to dispose of, and the types and size(s) of containers that the waste is in.

Waste Type and Cost

There is a small handling fee involved in the collection of hazardous waste from your business. Disposal costs depend on the type of waste.

Aerosols	$1.29/lb.
Automobile motor oil	$.73/gal.
Anti-freeze	$1.57/gal.
Contaminated oil	$4.48/gal.
Car batteries	$.62/ea.
Corrosive liquids, solids	$2.80/lb.
Flammable solids, liquids	$1.57/lb.
Latex Paint	$.73/lb.
Mercury	$10.08/lb.
NiCad/Alkaline Batteries	$2.13/lb.
Oil Base Paints	$1.00/lb.
Oil Filters	$.56/ea.
Oxidizers	$9.63/lb.
PCB Ballasts	$5.94/lb.
Pesticides (most)	$2.91/lb.
Photofixer, developer	$4.31/gal.
Television & Monitors	$11.20/ea.
Additional Handling	$138.00/hr.

Rates subject to change without notice

WE CANNOT ACCEPT

- Radioactives
- Water reactives
- Explosives
- Compressed gas cylinders
- Medical or biohazardous waste
- Asbestos
- Remediation wastes

HAZARDOUS WASTE

WHY IS THE FIRE DEPARTMENT COLLECTING HAZARDOUS WASTE?

Small Quantity Generators often have difficulty disposing of small quantities of hazardous waste. Hazardous waste companies usually have a minimum amount of waste that they will pick up, or charge a minimum fee for service. Typically, the minimum fee exceeds the cost of disposal for the hazardous waste. This leaves the small quantity generator in a difficult situation. Some respond by storing hazardous waste until it becomes economical for the hazardous waste transporter to pick it up, putting the business out of compliance by exceeding regulatory accumulation time limits. Other businesses simply store their hazardous wastes indefinitely, creating an unsafe work environment and exceeding accumulation time limits. Yet other businesses attempt to illegally dispose of their waste at household hazardous waste collection facilities. These facilities are not legally permitted to accept commercial wastes, nor are prepared to provide legal documentation for commercial hazardous waste disposal. In answer to the problems identified above, the San Bernardino County Fire Department Household Hazardous Program instituted the Conditionally Exempt Small Quantity Generator Program.

PAYMENT FOR SERVICES

The CESQG Program will prepare an invoice for your business at the time of service. You can pay at the time of service with cash or a check, or you can mail your payment to the Fire Department within 30 days. Please note that we do not accept credit card payments. The preferred method of payment is to handle payment at time of service. Additional charges may apply for accounts not paid within 30 days.

ARE THERE ANY OTHER WAYS THAT I CAN SAVE MONEY ON HAZARDOUS WASTE DISPOSAL?

Yes! First, start by reducing the amount of waste that you produce by changing processes or process chemicals, at your business. Next, examine if there is a way that you can recycle your waste back into your processes. Network with similar businesses or trade associations for waste minimization and pollution prevention solutions.

WHAT IF YOUR BUSINESS DOES NOT QUALIFY?

Call the San Bernardino County Fire Department Field Services Division for assistance with hazardous waste management at 909-386-8401. If you reduce the amount of waste you generate each month to 27 gallons or less, you may qualify in the future.

WHAT HAPPENS TO YOUR HAZARDOUS WASTE?

Hazardous waste collected by the CESQG Program is transported to a state permitted processing facility in San Bernardino. The waste is further processed at this point and packaged for off-site recycling (oil filters, oil, latex paint, antifreeze, and batteries) or destructive incineration (pesticides, corrosives, flammables, oil based paint).

San Bernardino County Fire Department
CESQG Program
2824 East "W" Street
San Bernardino, CA 92415-0799
Phone: 909-382-5401
Fax: 909-382-5413
www.sbcfire.org/hazmat/hhw.asp
Email: jschwab@sbcfire.org

WHEN WORKING OUTDOORS USE THE 3Cs

CUANDO TRABAJE AL AIRE LIBRE UTILICE LAS 3Cs

CONTROL | CONTROL

Locate the nearest storm drain and ensure nothing can enter or be discharged into it.
Ubique el desagüe de aguas pluviales más cercano y asegúrese de que nada pueda ingresar a éste ni descargarse en él.

CONTAIN | CONTENER

Isolate your area to prevent material from potentially flowing or being blown away.
Aísle su área para evitar que el material pueda discurrirse o ser llevado por el viento.

CAPTURE | CAPTURAR

Sweep up debris and place it in the trash. Clean up spills with an absorbent material (e.g. kitty litter) or vacuum with a Wet-Vac and dispose of properly.
Recoja los restos y colóquelos en la basura. Limpie los derrames con un material absorbente (como la arena para gatos) o aspírelos con una Wet-Vac (aspiradora de humedad) y deséchelos correctamente.

COMMERCIAL LANDSCAPE

Yard waste, sediments, and toxic lawn/garden chemicals used in commercial landscape maintenance often make their way into the San Bernardino County storm drain system and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates local waterways, making them unsafe for people and wildlife. Following these best management practices will prevent pollution, comply with regulations and protect public health.

Recycle Yard Waste
Recycle leaves, grass clippings and other yard waste. Do not blow, sweep, rake or hose yard waste into the street. Try grasscycling - the natural recycling of grass by leaving clippings on the lawn when mowing. Grass clippings willquickly decompose, returning valuable nutrients to the soil. Further information can be obtained at www.calrecycle.ca.gov/organics.

Use Fertilizers, Herbicides and Pesticides Safely
Fertilizers, herbicides and pesticides are often carried into the storm drain system by sprinkler runoff. Use of natural, non-toxic alternatives to the traditional fertilizers, herbicides and pesticides is highly recommended. If you must use chemical fertilizers, herbicides, or pesticides:

- Spot apply pesticides and herbicides, rather than blanketing entire areas.
- Avoid applying near curbs and driveways, and never apply before a rain.
- Apply fertilizers as needed, when plants can best use it, and when the potential for it being carried away by runoff is low.

Recycle Hazardous Waste
Pesticides, fertilizers, herbicides and motor oil contaminate landfills and should be disposed of through a Hazardous Waste Facility, which accepts these types of materials. For information on proper disposal call, (909) 386-8401.

Use Water Wisely
Conserve water and prevent runoff by controlling the amount of water and direction of sprinklers. Sprinklers should be on long enough to allow water to soak into the ground but not so long as to cause runoff. Periodically inspect, fix leaks and realign sprinkler heads. Plant native vegetation to reduce the need of water, fertilizers, herbicides, and pesticides.

Prevent Erosion
Erosion washes sediments, debris and toxic runoff into the storm drain system, polluting waterways.

- Prevent erosion and sediment runoff by using ground cover, berms and vegetation down-slope to capture runoff.
- Avoid excavation or grading during wet weather.

Store Materials Safely
Keep landscaping materials and debris away from the street, gutter and storm drains. On-site stockpiles of materials must be covered with plastic sheeting and surrounded with sand bags to protect from rain, wind and runoff.

SIDEWALK, PLAZA, ENTRY MONUMENT & FOUNTAIN MAINTENANCE

Pollutants on sidewalks and other pedestrian traffic areas and plazas are typically due to littering and vehicle use. Fountain water containing chlorine and copperbased algaecides is toxic to aquatic life. Proper inspection, cleaning, and repair of pedestrian areas and HOA owned surfaces and structures can reduce pollutant runoff from these areas. Maintaining these areas may involve one or more of the following activities:

1. **Surface Cleaning**
2. **Graffiti Cleaning**
3. **Sidewalk Repair**
4. **Controlling Litter**
5. **Fountain Maintenance**

POLLUTION PREVENTION:

Pollution prevention measures have been considered and incorporated in the model procedures. Implementation of these measures may be more effective and reduce or eliminate the need to implement other more complicated or costly procedures. Possible pollution prevention measures for sidewalk, plaza, and fountain maintenance and cleaning include:

- Use dry cleaning methods whenever practical for surface cleaning activities.
- Use the least toxic materials available (e.g. water based paints, gels or sprays for graffiti removal).
- Once per year, educate HOA staff and tenants on pollution prevention measures.

MODEL PROCEDURES:

1. Surface Cleaning

Discharges of wash water to the storm water drainage system from cleaning or hosing of impervious surfaces is prohibited.

Sidewalks, Plazas

✓ Use dry methods (e.g. sweeping, backpack blowers, vacuuming) whenever practical to clean sidewalks and plazas rather than hosing, pressure washing, or steam cleaning. DO NOT sweep or blow material into curb; use devices that contain the materials.

✓ If water must be used, block storm drain inlets and contain runoff. Discharge wash water to landscaping or contain and dispose of properly.

SIDEWALK, PLAZA, ENTRY MONUMENT & FOUNTAIN MAINTENANCE

Parking Areas, Driveways, Drive-thru

✓ Parking facilities should be swept/vacuumed on a regular basis. Establish frequency of public parking lot sweeping based on usage and field observations of waste accumulation.

✓ If water must be used, block storm drain inlets and contain runoff. Discharge wash water to landscaping or contain and dispose of properly.

✓ Sweep all parking lots at least once before the onset of the wet season.

✓ Use absorbents to pick up oil; then dry sweep.

✓ Appropriately dispose of spilled materials and absorbents.

OPTIONAL:

- Consider increasing sweeping frequency based on factors such as traffic volume, land use, field observations of sediment and trash accumulation, proximity to water courses, etc.

Building Surfaces, Decks, etc., without loose paint

✓ Use high-pressure water, no soap.

✓ If water must be used, block storm drain inlets and contain runoff. Discharge wash water to landscaping or contain and dispose of properly.

Unpainted Building Surfaces, Wood Decks, etc.

✓ If water must be used, block storm drain inlets and contain runoff. Discharge wash water to landscaping or contain and dispose of properly.

✓ Use biodegradable cleaning agents to remove deposits.

✓ Make sure pH is between 6.5 and 8.5 THEN discharge to landscaping (if cold water without a cleaning agent) otherwise dispose of properly.

2. Graffiti Cleaning

Graffiti Removal

✓ Avoid graffiti abatement activities during rain events.

✓ When graffiti is removed by painting over, implement the procedures under Painting and Paint Removal in the Roads, Streets, and Highway Operation and Maintenance procedure sheet.

✓ Protect nearby storm drain inlets prior to removing graffiti from walls, signs, sidewalks, or other structures needing graffiti abatement. Clean up afterwards by sweeping or vacuuming thoroughly, and/or by using absorbent and properly disposing of the absorbent.

SIDEWALK, PLAZA, ENTRY MONUMENT & FOUNTAIN MAINTENANCE

✓ Note that care should be taken when disposing of waste since it may need to be disposed of as hazardous waste.

OPTIONAL:

• Consider using a waterless and non-toxic chemical cleaning method for graffiti removal (e.g. gels or spray compounds).

3. Sidewalk Repair

Surface Removal and Repair

✓ Schedule surface removal activities for dry weather if possible.

✓ Avoid creating excess dust when breaking asphalt or concrete.

✓ Take measures to protect nearby storm drain inlets prior to breaking up asphalt or concrete (e.g. place hay bales or sand bags around inlets). Clean afterwards by sweeping up material.

✓ Designate an area for clean up and proper disposal of excess materials.

✓ Remove and recycle as much of the broken pavement as possible.

✓ When making saw cuts in pavement, use as little water as possible. Cover each storm drain inlet with filter fabric during the sawing operation and contain the slurry by placing straw bales, sandbags, or gravel dams around the inlets. After the liquid drains shovel or vacuum the slurry, remove from site and dispose of properly.

✓ Always dry sweep first to clean up tracked dirt. Use a street sweeper or vacuum truck. Do not dump vacuumed liquid in storm drains. Once dry sweeping is complete, the area may be hosed down if needed. Discharge wash water to landscaping, pump to the sanitary sewer if permitted to do so or contain and dispose of properly.

Concrete Installation and Repair

✓ Avoid mixing excess amounts of fresh concrete or cement mortar on-site. Only mix what is needed for the job.

✓ Wash concrete trucks off-site or in designated areas on-site, such that there is no discharge of concrete wash water into storm drain inlets, open ditches, streets, or other storm water conveyance structures. (See Concrete Waste Management BMP WM – 8)

SIDEWALK, PLAZA, ENTRY MONUMENT & FOUNTAIN MAINTENANCE

- ✓ Store dry and wet concrete materials under cover, protected from rainfall and runoff and away from drainage areas. After job is complete remove temporary stockpiles (asphalt materials, sand, etc.) and other materials as soon as possible.
- ✓ Return leftover materials to the transit mixer. Dispose of small amounts of excess concrete, grout, and mortar in the trash.
- ✓ When washing concrete to remove fine particles and expose the aggregate, contain the wash water for proper disposal.
- ✓ Do not wash sweepings from exposed aggregate concrete into the street or storm drain. Collect and return sweepings to aggregate base stock pile, or dispose in the trash.
- ✓ Protect applications of fresh concrete from rainfall and runoff until the material has hardened.

4. Litter Control

- ✓ Enforce anti-litter laws.
- ✓ Provide litter receptacles in busy, high pedestrian traffic areas of the community, at recreational facilities, and at community events.
- ✓ Cover litter receptacles and clean out frequently to prevent leaking/spillage or overflow.

OPTIONAL:

- Post "No Littering" signs.

5. Fountain Maintenance

- ✓ Do not use copper-based algaecides. Control algae with chlorine or other alternatives, such as sodium bromide.
- ✓ Allow chlorine to dissipate for a few days and then recycle/reuse water by draining it gradually onto a landscaped area. Water must be tested prior to discharge to ensure that chlorine is not present (concentration must be less than 0.1 ppm).
- ✓ Contact local agency for approval to drain into sewer or storm drain.
- ✓ Avoid mixing excess amounts of fresh concrete or cement mortar on-site. Only mix what is needed for the job.

EQUIPMENT MAINTENANCE & REPAIR

Vehicle or equipment maintenance has the potential to be a significant source of stormwater pollution. Engine repair and service (parts cleaning, spilled fuel, oil, etc.), replacement of fluids, and outdoor equipment storage and parking (dripping engines) can all contaminate stormwater. Conducting the following activities in a controlled manner will reduce the potential for stormwater contamination:

1. **General Maintenance and Repair**
2. **Vehicle and Machine Repair**
3. **Waste Handling/Disposal**

Related vehicle maintenance activities are covered under the following program headings in this manual: "Vehicle and Equipment Cleaning", "Vehicle and Equipment Storage", and "Vehicle Fueling".

POLLUTION PREVENTION:

Pollution prevention measures have been considered and incorporated in the model procedures. Implementation of these measures may be more effective and reduce or eliminate the need to implement other more complicated or costly procedures. Possible pollution prevention measures for equipment maintenance and repair include:

- Review maintenance activities to verify that they minimize the amount of pollutants discharged to receiving waters. Keep accurate maintenance logs to evaluate materials removed and improvements made.
- Switch to non-toxic chemicals for maintenance when possible.
- Choose cleaning agents that can be recycled.
- Minimize use of solvents. Clean parts without using solvents whenever possible. Recycle used motor oil, diesel oil, and other vehicle fluids and parts whenever possible.
- Once per year, educate HOA staff and tenants on pollution prevention measures.

EQUIPMENT MAINTENANCE & REPAIR

MODEL PROCEDURES:

1. General Maintenance and Repair

General Guidelines

➔ *Note: Permission must be obtained for any discharge of wash water to the sanitary sewer from the local sewering agency.*

- ✓ Review maintenance activities to verify that they minimize the amount of pollutants discharged to receiving waters. Keep accurate maintenance logs to evaluate materials removed and improvements made.
- ✓ Regularly inspect vehicles and equipment for leaks.
- ✓ Move activity indoors or cover repair area with a permanent roof if feasible.
- ✓ Minimize contact of stormwater with outside operations through berming the local sewering and drainage routing.
- ✓ Place curbs around the immediate boundaries of the process equipment.
- ✓ Clean yard storm drain inlets regularly and stencil them.

Good Housekeeping

- ✓ Avoid hosing down work areas. If work areas are washed and if discharge to the sanitary sewer is allowed, treat water with an appropriate treatment device (e.g. clarifier) before discharging. If discharge to the sanitary sewer is not permitted, pump water to a tank and dispose of properly.
- ✓ Collect leaking or dripping fluids in drip pans or container. Fluids are easier to recycle or dispose of properly if kept separate.
- ✓ Keep a drip pan under the vehicle while you unclip hoses, unscrew filters, any discharge of or remove other parts. Place a drip pan under any vehicle that might leak while you work on it to keep splatters or drips off the shop floor.
- ✓ Educate employees on proper handling and disposal of engine fluids.
- ✓ Promptly transfer used fluids to the proper waste or recycling drums. Don't leave full drip pans or other open containers lying around.
- ✓ Do not pour liquid waste to floor drains, sinks, outdoor storm drain inlets, or other storm drains or sewer connections.
- ✓ Post signs at sinks and stencil outdoor storm drain inlets.

2. Vehicle Repair

General Guidelines

- ✓ Perform vehicle fluid removal or changing inside of a building or in a contained covered area, where feasible, to prevent the run-on of stormwater and the runoff of spills.
- ✓ Regularly inspect vehicles and equipment for leaks, and repair as needed.

- ✓ Use secondary containment, such as a drain pan or drop cloth, to catch spills or leaks when removing or changing fluids.
- ✓ Immediately drain all fluids from wrecked vehicles. Ensure that the drain pan or drip pan is large enough to contain drained fluids (e.g. larger pans are needed to contain antifreeze, which may gush from some vehicles).
- ✓ Promptly transfer used fluids to the proper waste or recycling drums. Don't leave full drip pans or other open containers lying around.
- ✓ Recycle used motor oil, diesel oil, and other vehicle fluids and parts whenever possible.
- ✓ Oil filters disposed of in trash cans or dumpsters can leak oil. Place the oil filter in a funnel over a waste oil recycling drum to drain excess oil before disposal. Oil filters can also be recycled. Ask your oil supplier or recycler about recycling oil filters.
- ✓ Store cracked batteries in a non-leaking secondary container and dispose of properly at recycling facilities or at County hazardous waste disposal site.

Vehicle Leak and Spill Control

- ✓ Use absorbent materials on small spills. Remove the absorbent materials promptly and dispose of properly.
- ✓ Place a stockpile of spill cleanup materials where it will be readily accessible.
- ✓ Sweep floor using dry absorbent material.

3. Machine Repair

- ✓ Keep equipment clean; don't allow excessive build-up of oil or grease.
- ✓ Minimize use of solvents.
- ✓ Use secondary containment, such as a drain pan or drop cloth, to catch spills or leaks when removing or changing fluids.
- ✓ Perform major equipment repairs at the corporation yard, when practical.
- ✓ Following good housekeeping measures in Vehicle Repair section.

4. Waste Handling/Disposal

Waste Reduction

- ✓ Prevent spills and drips of solvents and cleansers to the shop floor.
- ✓ Do liquid cleaning at a centralized station so the solvents and residues stay in one area. Recycle liquid cleaners when feasible.

✓ Locate drip pans, drain boards, and drying racks to direct drips back into a solvent sink or fluid holding tank for reuse.

OPTIONAL:

- If possible, eliminate or reduce the amount of hazardous materials and waste by substituting non-hazardous or less hazardous material:

  -Use non-caustic detergents instead of caustic cleaning for parts cleaning.

  -Use a water-based cleaning service and have tank cleaned. Use detergent-based or water-based cleaning systems in place of organic solvent degreasers.

  -Replace chlorinated organic solvents with non-chlorinated solvents. Non-chlorinated solvents like kerosene or mineral spirits are less toxic and less expensive to dispose of properly. Check list of active ingredients to see whether it contains chlorinated solvents.

  -Choose cleaning agents that can be recycled.

Recycling

OPTIONAL:

- Separate wastes for easier recycling. Keep hazardous and non-hazardous wastes separate, do not mix used oil and solvents, and keep chlorinated solvents separate from non-chlorinated solvents.

- Label and track the recycling of waste material (e.g. used oil, spent solvents, batteries).

- Purchase recycled products to support the market for recycled materials.

LIMITATIONS:

Space and time limitations may preclude all work being conducted indoors. It may not be possible to contain and clean up spills from vehicles/equipment brought on-site after working hours. Dry floor cleaning methods may not be sufficient for some spills – see spill prevention and control procedures sheet. Identification of engine leaks may require some use of solvents.

POOL MAINTENANCE

Pool chemicals and filter solids, when discharged to the City streets, gutters or storm drans, DO NOT GET TREATED before reaching the Santa Ana River. Chlorine, acid cleaning chemicals and metal-based algaecides used in pools can kill beneficial organisms in the food chain and pollute our drinking water.

When emptying your swimming pool, spa or fountain, please use one of the following best management practices to prevent water pollution:

- Reuse the water as landscape irrigation
- Empty the water into the sewer between midnight and 6:00 am
- Remove solids and floating debris and dispose of in the trash, de-chlorinate the water to a chlorine residual = 0, wait 24 hours, then discharge the water to the street or storm drain
- Try not to use metal-based algaecides (i.e. copper sulfate) in your pool or spa. If you have, empty your pool or spa into the sewer. *Prior to discharging pool water into the sanitary sewer system, contact your local agency.*
- If the pool contains algae and mosquito larvae, discharge the water to the sewer

When acid cleaning or other chemical cleaning:

- Neutralize the pool water to pH of 6.5 to 8.5, then discharge to the sewer

For swimming pool and spa filter backwash:

- Dispose of solids into trash bag, then wash filter into a landscape area
- Settle, dispose of solids in trash and discharge water to the sewer, never to the storm drain

» For Residents

*The following is a preview of the information we have available to residents. For more fact sheets, visit **sbcountystormwater.org***

Bear Lake – City Public Service Yard
42040 Garstin Dr. (cross street: Big Bear Blvd.)
Big Bear Lake, CA 92315
Hours: 2nd & 4th Saturday of each month,
9 am – 12 noon
(800) 645 – 9228

Chino – Chino City Public Works Services Center
5050 Schaefer Ave. (cross street: 4th St.)
Chino, CA 91710
Hours: 2nd & 4th Saturday of each month, 8 am – 1 pm
(909) 591 - 9843

Fontana (For City of Fontana residents only)
16454 Orange Way (cross street: Cypress Ave.)
Fontana, CA 92335
Hours: Saturdays, 8 am – 12 noon
(909) 350 – 6531

City of Ontario Household Hazardous Waste Facility
1430 S. Cucamonga Ave.
Ontario, CA 91761
Hours: Fridays & Saturdays, 9 am – 2 pm
(909) 395 – 2040

Rancho Cucamonga – Rancho Cucamonga HHW Facility
12158 Baseline Rd. (cross street: Rochester Ave.)
Rancho Cucamonga, CA 91739
Hours: Saturdays, 8 am – 12 noon
(909) 382 – 5401

Redlands – Redlands City Yard
500 Kansas St. (cross street: Park Ave.)
Redlands, CA 92373
Hours: Saturdays, 9:30 am – 12:30 pm
(909) 798 – 7600

Rialto – City Maintenance Yard
246 Willow Ave. (cross street: Rialto Ave.)
Rialto, CA 92376
Hours: 2nd & 4th Friday of each month, 2 pm – 4 pm
2nd & 4th Saturday of each month, 10 am – 2 pm
(909) 820 – 2622

San Bernardino – San Bernardino International Airport
2824 East "W" St., Building 302
(cross street: Victoria Ave.)
San Bernardino, CA
Hours: Monday – Friday, 9 am – 4 pm
(909) 382 – 5401

Upland – Upland City Yard
1370 N. Benson Ave. (cross street: 14th St.)
Upland, CA 91786
Hours: Saturdays, 9 am – 2 pm
(909) 382 – 5401

WE DID IT OURSELVES AND WE DID IT RIGHT

When painting your home, protect your family and community.

- **PAINTS** that are water-based are less toxic and should be used whenever possible.
- **BRUSHES** with water-based paint should be washed in the sink. Those with oil-based paint should be cleaned with paint thinner.
- **SAFELY** dispose of unwanted paint and paint thinner. The County of San Bernardino offers 9 HHW Centers that accept paint and other household hazardous waste from residents FREE of charge. For a list of acceptable materials, location information, and hours of operation call 1-800-OILY CAT.

VEHICLE MAINTENANCE

Oil, grease, anti-freeze and other toxic automotive fluids often make their way into the San Bernardino County storm drain system, and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates waterways, making them unsafe for people and wildlife. Follow these best management practices to prevent pollution and protect public health.

Cleaning Auto Parts
Scrape parts with a wire brush or use a bake oven rather than liquid cleaners. Arrange drip pans, drying racks and drain boards so that fluids are directed back into the parts washer or the fluid holding tank. Do not wash parts or equipment in a sink, parking lot, driveway or street.

Storing Hazardous Waste
Keep your liquid waste segregated. Many fluids can be recycled via hazardous waste disposal companies if they are not mixed. Store all materials under cover with spill containment or inside to prevent contamination of rainwater runoff.

Preventing Leaks and Spills
Conduct all vehicle maintenance inside of a garage. Place drip pans underneath vehicle to capture fluids. Use absorbent materials instead of water to clean work areas.

Cleaning Spills
Use dry methods for spill cleanup (sweeping, absorbent materials). To report accidental spills into the street or storm drain call (877) WASTE18 or 911.

Proper Disposal of Hazardous Waste
Dispose of household hazardous waste by taking it to your nearest household hazardous waste center. For more information, call 1-800-OILY CAT or check out sbcountystormwater.org/Disposal.html

PET WASTE DISPOSAL

FREE

DOGGIE WASTE BAGS

Remember to pick up after your pet every time to keep San Bernardino County clean and healthy!

To RECEIVE your

FREE CONTAINER

visit us online at

sbcountystormwater.org/dog

In the event of a spill or discharge to a storm drain or waterway, contact San Bernadino County Stormwater immediately: (877) WASTE18 | sbcountystormwater.org/report

sbcountystormwater.org

Big Bear • Chino • Chino Hills • Colton • Fontana • Grand Terrace • Highland • Loma Linda • Montclair • Ontario • Rancho Cucamongo
Redlands • Rialto • San Bernadino • San Bernadino County • San Bernadino County Flood Control District • Upland • Yucaipa

» Get In Touch With Us Online!

» Website
sbcountystormwater.org

» eUpdates
sbcountystormwater.org/newsletter

» Facebook
facebook.com/sbcountystormwater

» YouTube
youtube.com/sbcountystormwater

» Report Pollution Violations
sbcountystormwater.org/report

» Email
info@sbcountystormwater.org

Appendix E
Water Quality Calculations

HDR | ONE COMPANY *Many Solutions™*

Project: RPRP, Prelim Eng Phase	Computed: B.F.	Date: 12-1-12	
Subject: WQ Calcs - total project	Checked:	Date:	
Task: Env (Task 9)	Page: 1	of: 2	
Job #: 43-170063	No:		

I. BMP Drainage Area

Project total = 21 ac. (impervious, prop. design)
During PS&E, this area will divided further based on station/parking lot and layover design.

II. NOAA Atlas 14 Precipitation Depth Map

2yr - 1hr. rainfall value $\Rightarrow I_{2yr} = 0.57$

A. (1) Determine C_{BMP} (composite runoff coefficient)

Assume area associated w/ proposed imperviousness are for stations, parking lots, and layover facility.

(2) BMP Drainage Area Region $\Rightarrow$ valley

(3) Target BMP Flow Rate (AKA WQF)

Per Table D-1

Regression coefficient $I = 0.2787$

Hence $I_{BMP} = I_{2y} \times$ Reg. Coeff. $\times 2$

$= 0.57 \times 0.2787 \times 2$

$= 0.32$ in/hr.

$WQF = C_{BMP} \times I_{BMP} \times A = 0.90 \times 0.32 \times 21$

WQF = 6 cfs

HDR | ONE COMPANY *Many Solutions™*

Project: RMRP, Prelim Eng. Phase	Computed: B.R.	Date:	12-1-12
Subject: WQ Calcs - total Project	Checked:	Date:	
Task: Env (Task 9)	Page: 2	of:	2
Job #: 43-170063	No:		

B. Target BMP volume (AKA WQV)

① watershed impervious ratio
Assume for commercial use, $i = 0.90$

② Composite Runoff coefficient

$$C_{BMP} = 0.858 i^3 - 0.78 i^2 + 0.774 i + 0.04$$
$$= 0.858(0.9)^3 - 0.78(0.9)^2 + 0.774(0.90) + 0.04$$
$$= 0.63 - 0.63 + 0.70 + 0.04$$
$$= 0.74$$

③ Located in Valley Area

④ P_6 = I_{2y} x regression coefficient
= 0.57 x 1.4807
= 0.84 in (6 hr mean storm rainfall)

⑤ Assume drawdown time = 48 hr.
a = 1.963

⑥ maximized detention volume (P_o)
$P_o = a \times C_{BMP} \times P_6 = 1.963 \times 0.74 \times 0.84$
= 1.22 in.

V_o = BMP volume (AKA WQV)
= $(P_o \times A)/12$
= $(1.22 \times 21)/12$
= 2.1 ac-ft

INSTRUCTIONS FOR ESTIMATING VOLUME- AND FLOW-BASED BMP DESIGN RUNOFF QUANTITIES[4]

1) Identify the "BMP Drainage Area" that drains to the proposed BMP element. This includes all areas that will drain to the proposed BMP element, including pervious areas, impervious areas, and off-site areas, whether or not they are directly or indirectly connected to the BMP element. Calculate the BMP Drainage Area (A) in acres.

2) Outline the Drainage Area on the NOAA Atlas 14 Precipitation Depths (2-year 1hour Rainfall) map (Figure D-1).

3) Determine the area-averaged 2-year 1-hour rainfall value for the Drainage Area outlined above.

A. Flow-Based BMP Design

1) Calculate the composite runoff coefficient, CBMP, as defined in part B.2, below.

2) Determine which Region the BMP Drainage Area is located in (Valley, Mountain or Desert).

3) Determine BMP design rainfall intensity, IBMP, by multiplying the area-averaged 2-year 1-hour value from the NOAA Atlas 14 map by the appropriate regression coefficient from Table D-1 ("I"), and then multiplying by the safety factor specified in the criteria—usually a factor of 2.

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[4] Rainfall analysis to develop regression coefficients in Table D-1 and modifications to the NOAA Atlas 14 map were conducted by:

Hromadka II, T.V., Professor Emeritus, Department of Mathematics, California State University, Fullerton, and Adjunct Professor, Department of Mathematical Sciences, United States Military Academy, West Point, NY

Laton, W.R , Assistant Professor, Department of Geological Sciences, California State University, Fullerton

Picciuto J.A.., Assistant Professor, Department of Mathematical Sciences, United States Military Academy, West Point, NY

With assistance from:

Rene Perez, M.S. Candidate, Department of Geological Sciences, California State University, Fullerton, and

Jim Friel, Ph.D. Professor Emeritus, Department of Mathematics, California State University, Fullerton

Reported as follows:

1. Hromadka II, T.V., Laton, W.R., and Picciuto J.A., 2005. Estimating Runoff Quantities for Flow and Volume-based BMP Design. Final Report to the San Bernardino County Flood Control District.
2. Laton, W.R., Hromadka II, T.V., and Picciuto J.A., 2005. Estimating Runoff Quantities for Flow and Volume-based BMP Design (submitted). Journal of the American Water Resources Association.

4) Calculate the target BMP flow rate, Q, by using the following formula (see Table D-2 below for limitations on the use of this formula):

$$Q = C_{BMP} \cdot I_{BMP} \cdot A$$

where: **Q** = flow in ft^3/s

I_{BMP} = BMP design rainfall intensity, in inches/hour

A = Drainage Area in acres

C_{BMP} = composite runoff coefficient

Table D-1: Regression Coefficients for Intensity (I) and 6-hour mean storm rainfall (P**6**).

Quantity	**Valley** 85% upper confidence limit	**Mountain** 85% upper confidence limit	**Desert** 85% upper confidence limit
I	**0.2787**	**0.3614**	**0.3250**
P6	**1.4807**	**1.9090**	**1.2371**

Table D-2: Use of the flow-based formula for BMP Design (CASQA 2003).

	Composite Runoff Coefficient, "C"			
BMP Drainage Area (Acres)	**0.00 to 0.25**	**0.26 to 0.50**	**0.51 to 0.75**	**0.76 to 1.00**
0 to 25	**Caution**	**Yes**	**Yes**	**Yes**
26 to 50	**High Caution**	**Caution**	**Yes**	**Yes**
51 to 75	**Not Recommended**	**High Caution**	**Caution**	**Yes**
76 to 100	**Not Recommended**	**High Caution**	**Caution**	**Yes**

If the flow-based BMP formula use case, as determined by Table D-2, shows "Caution," "High Caution," or "Not Recommended," considering the project's characteristics, then he project proponent must calculate the BMP design flow using the unit hydrograph method, as specified in the most current version of the San Bernardino County Hydrology Manual, using the design storm pattern with rainfall return frequency such that the peak one hour rainfall depth equals the 85th-percentile 1-hour rainfall multiplied by two.

B. Volume-Based BMP Design

1) Calculate the "Watershed Imperviousness Ratio", i, which is equal to the percent of impervious area in the BMP Drainage Area divided by 100.

2) Calculate the composite runoff coefficient CBMP for the Drainage Area above using the following equation:

$$\mathbf{CBMP = 0.858i^3 - 0.78i^2 + 0.774i + 0.04}$$

where: **CBMP** = composite runoff coefficient; and,

i = watershed imperviousness ratio.

3) Determine which Region the Drainage Area is located in (Valley, Mountain or Desert).

4) Determine the area-averaged "6-hour Mean Storm Rainfall", P6, for the Drainage Area. This is calculated by multiplying the area averaged 2-year 1-hour value by the appropriate regression coefficient from Table 1.

5) Determine the appropriate drawdown time. Use the regression constant a = 1.582 for 24 hours and a = 1.963 for 48 hours. *Note: Regression constants are provided for both 24 hour and 48 hour drawdown times; however, 48 hour drawdown times should be used in most areas of California. Drawdown times in excess of 48 hours should be used with caution as vector breeding can be a problem after water has stood in excess of 72 hours. (Use of the 24 hour drawdown time should be limited to drainage areas with coarse soils that readily settle and to watersheds where warming may be detrimental to downstream fisheries.)*

6) Calculate the "Maximized Detention Volume", P0, using the following equation:

$$\mathbf{P0 = a \cdot CBMP \cdot P6}$$

where: **P0** = Maximized Detention Volume, in inches

a = 1.582 for 24 hour and a = 1.963 for 48 hour drawdown,

CBMP = composite runoff coefficient; and,

P6 = 6-hour Mean Storm Rainfall, in inches

7) Calculate the "Target Capture Volume", V0, using the following equation:

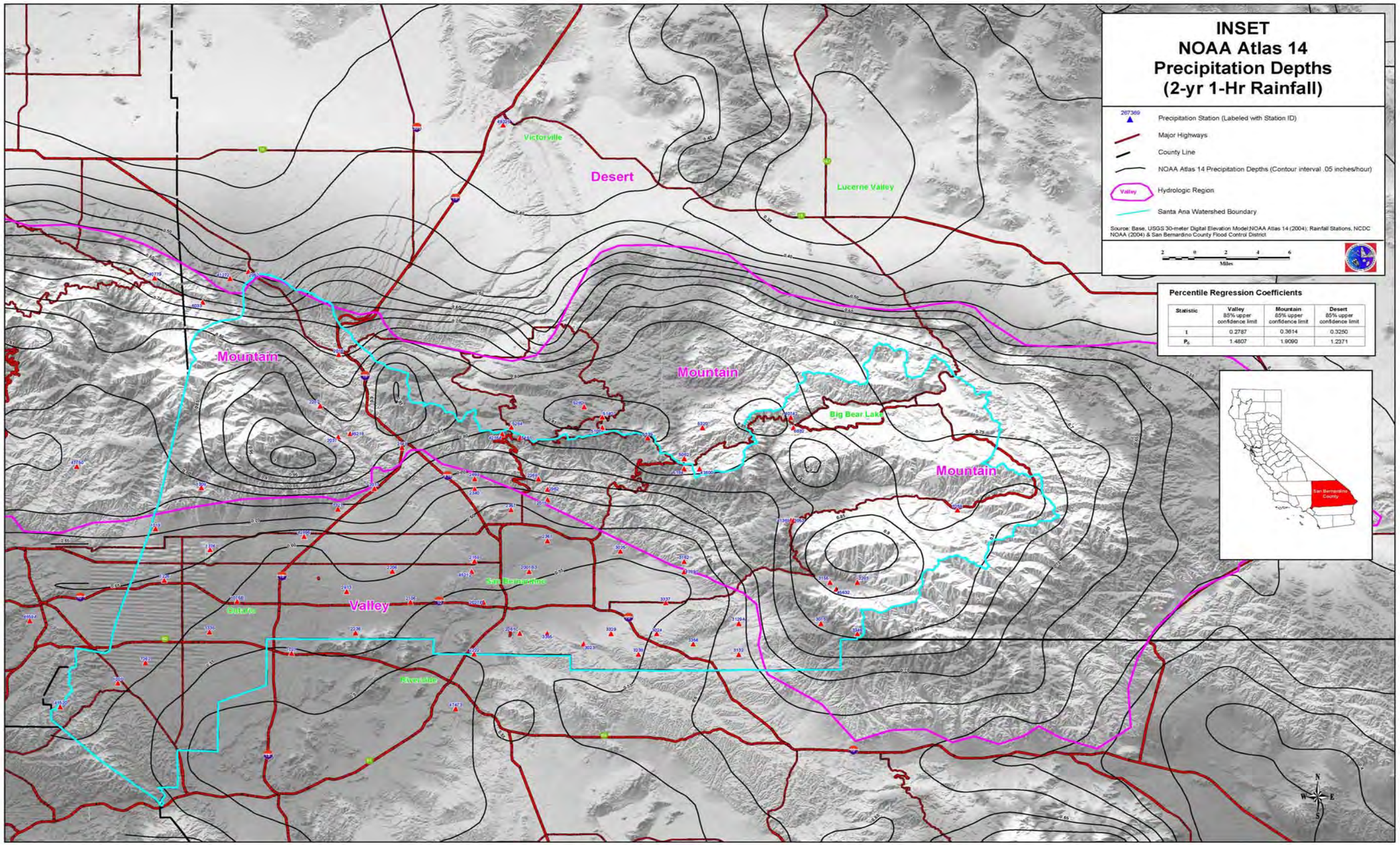
$$\mathbf{V0 = (P0 \cdot A) / 12}$$

where: **V0** = Target Capture Volume, in acre-feet

P0 = Maximized Detention Volume, in inches; and,

A = BMP Drainage Area, in acres

Figure D-1: NOAA Atlas 14 Inset Map.



Appendix F
Construction Risk Assessment

Redlands Passenger Rail Project, Preliminary Engineering Phase
SWPPP Risk Determination Analysis

There are two aspects involved in developing a risk determination analysis for a specific project site. The first is to determine the Sediment Risk which involves an R-factor (rainfall erosivity), K-factor (soil erodibility) and LS-factor (topographic). The second is to determine the Receiving Water Risk which involves the impact runoff will have on the receiving water body. The Risk Determination Worksheet provides steps for determining these risk factors. See Attachments.

The following is the methodology used to determine the factors involved to calculate the Risk Level for the Project:

Sediment Risk

There are two approaches for determining the sediment risk level according to the Construction General Permit (CGP); GIS Map method or Site-Specific method. This analysis was based on the Site-Specific method. The sediment risk is based upon the RUSLE equation with the three (3) aforementioned factors and is separated into three (3) risk level categories; < 15 tons/acre (low), >15 and <75 tons/acre (medium) and >75 tons/acre (high).

R-Factor

The R-factor is based upon the location and duration of construction. The location used to determine the R-factor was done in Google Earth. It is anticipated that the construction schedule will begin 01/01/2015 and end on 12/31/2017. At the time this document was completed, EPA's Rainfall Erosivity Factor Calculator (http://cfpub.epa.gov/npdes/stormwater/LEW/lewcalculator.cfm) was offline. In its place, the USEPA Fact Sheet 3.1 (Storm Water Phase II Final Rule, Construction Rainfall Erosivity Waiver) was utilized. Per associated Figure 1, the Erosivity Index Zone is 25. Per Table 1, the Erosivity Index (EI) from January 1, 2015 to December 31, 2017 is 300%. Per Figure 4, the Isoerodent Value is approximately 40 (see closeup view provided from Google Earth). Hence, the resultant R-factor is 120. See Attachments.

K-Factor

Based on site geotechnical data, two general K-Factors were provided; 0.17 and 0.42. The value 0.42 was used as the conservative value. The lower site-specific K-Factor is consistent with the value identified in Google Earth, generally ranging from 0.20 to 0.24. Hence, the resultant K-Factor is 0.42. See Attachments.

LS-Factor

HDR Engineering, Inc.
2280 Market Street
Suite 100
Riverside, CA 92501-2110
Phone: (951) 320-7300
Fax: (951) 320-7301
www.hdrinc.com

Based on the GIS data available from the SWRCB, Google Earth reflected the LS factors to vary from west to east as 1.19, 1.98, 0.99, and 0.82.

To be conservative, an average LS factor of 1.3 is assumed.

Based on the aforementioned factors, the Project's Sediment Risk is computed to be 65.52 tons/acre and is categorized as *Medium*. See Attachments.

Receiving Water Risk

A sediment sensitive watershed drains into a receiving water body (1) listed on EPA's approved CWA 303(d) list for sedimentation/siltation, turbidity with an approved TMDL or (2) designated with beneficial uses of SPAWN, COLD and MIGATORY. The Project discharges to the Santa Ana River Reach 4 and 5. According to the 2006 303(d) List and the 2010 Integrated Report, the Santa Ana River Reach 4 and 5 is not a water body that is impaired by sediment. This was also confirmed by the SWRCB GIS map data on Google Earth. In addition, the receiving water body's designated Beneficial Uses does not include SPAWN, COLD and MIGATORY. Hence, Santa Ana River Reach 4 and 5 are not considered a sediment sensitive watershed, and since both of these criteria do not pertain to the Project the resultant Receiving Water Risk is *Low*. See Attachments.

Overall Project

Based on the Sediment Risk and Receiving Water Risk categories, the entire Project is categorized as a combined ***Risk Level 2***. See Attachments.

Sincerely,

Bill Flores, PE, CPESC, CPSWQ, QSD
HDR Engineering, Inc.

	A	B	C
1	**Sediment Risk Factor Worksheet**		**Entry**
2	**A) R Factor**		
3	Analyses of data indicated that when factors other than rainfall are held constant, soil loss is directly proportional to a rainfall factor composed of total storm kinetic energy (E) times the maximum 30-min intensity (I30) (Wischmeier and Smith, 1958). The numerical value of R is the average annual sum of EI30 for storm events during a rainfall record of at least 22 years. "Isoerodent" maps were developed based on R values calculated for more than 1000 locations in the Western U.S. Refer to the link below to determine the R factor for the project site.		
4	http://cfpub.epa.gov/npdes/stormwater/LEW/lewCalculator.cfm		
5	**R Factor Value**		120
6	**B) K Factor (weighted average, by area, for all site soils)**		
7	The soil-erodibility factor K represents: (1) susceptibility of soil or surface material to erosion, (2) transportability of the sediment, and (3) the amount and rate of runoff given a particular rainfall input, as measured under a standard condition. Fine-textured soils that are high in clay have low K values (about 0.05 to 0.15) because the particles are resistant to detachment. Coarse-textured soils, such as sandy soils, also have low K values (about 0.05 to 0.2) because of high infiltration resulting in low runoff even though these particles are easily detached. Medium-textured soils, such as a silt loam, have moderate K values (about 0.25 to 0.45) because they are moderately susceptible to particle detachment and they produce runoff at moderate rates. Soils having a high silt content are especially susceptible to erosion and have high K values, which can exceed 0.45 and can be as large as 0.65. Silt-size particles are easily detached and tend to crust, producing high rates and large volumes of runoff. Use Site-specific data must be submitted.		
8	Site-specific K factor guidance		
9	**K Factor Value**		0.42
10	**C) LS Factor (weighted average, by area, for all slopes)**		
11	The effect of topography on erosion is accounted for by the LS factor, which combines the effects of a hillslope-length factor, L, and a hillslope-gradient factor, S. Generally speaking, as hillslope length and/or hillslope gradient increase, soil loss increases. As hillslope length increases, total soil loss and soil loss per unit area increase due to the progressive accumulation of runoff in the downslope direction. As the hillslope gradient increases, the velocity and erosivity of runoff increases. Use the LS table located in separate tab of this spreadsheet to determine LS factors. Estimate the weighted LS for the site prior to construction.		
12	LS Table		
13	**LS Factor Value**		1.3
14			
15	**Watershed Erosion Estimate (=RxKxLS) in tons/acre**		65.52
16	**Site Sediment Risk Factor**		**Medium**
17	Low Sediment Risk: < 15 tons/acre		
18	Medium Sediment Risk: >=15 and <75 tons/acre		
19	High Sediment Risk: >= 75 tons/acre		
20			

CALIFORNIA Water Boards

EDMUND G. BROWN JR.
GOVERNOR

MATTHEW RODRIQUEZ
SECRETARY FOR
ENVIRONMENTAL PROTECTION

State Water Resources Control Board

CONSTRUCTION GENERAL PERMIT
RISK ASSESSMENT R-FACTOR CALCULATION NOTIFICATION

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) GENERAL PERMIT FOR STORM WATER DISCHARGES ASSOCIATED WITH CONSTRUCTION AND LAND DISTURBANCE ACTIVITIES

State Water Resources Control Board Order No. 2009-0009-DWQ, as amended by 2010-0014-DWQ (CGP) requires that dischargers assessing Risk must calculate the Rainfall Erosivity Factor (R-Factor) in the Revised Universal Soil Loss Equation through the Environmental Protection Agency (EPA) Rainfall Erosivity Factor Calculator at: http://cfpub.epa.gov/npdes/stormwater/lew/lewcalculator.cfm

The week of February 13, 2012 the Rainfall Erosivity Factor Calculator became unavailable due to maintenance. EPA has approximated that maintenance may take at least 1 month to complete. Until that time, dischargers shall calculate their project R-factor using the Construction Erosivity Waiver Fact Sheet (Fact Sheet) provided by EPA at http://www.epa.gov/npdes/pubs/fact3-1.pdf (also attached). The Fact Sheet provides the instructions and references needed to calculate R-values for a one year period. Projects active for more than a one year period must calculate the R-factor for year 1, and multiply this value based on the estimated duration.

Please contact the Storm Water Help Desk if you have any questions. 1-866-563-3107 or stormwater@waterboards.ca.gov.

Examples:

1. ***Find the R value of a construction project in Sacramento, California with a duration of February 29, 2012 to September 1, 2014 (2.5 years).***

   Figure 1 - Erosivity Index Zone Map:
   The EI distribution zone is 23
   Table 1 – Erosivity Index Table:
   EI percentage February 29 to December 31: 100% – 25.7% = 74.3%
   EI percentage January 1 to February 29: 25.7% - 0.0% = 25.7%
   Total EI percentage for 1 year duration: 74.3% + 25.7% = 100%
   EI percentage February 29 to September 1 (0.5 year): 54.1% - 25.7% = 28.4%
   Figure 4 – Isoerodent Map of California:
   Interpolated annual erosion index for location: 35

R-Factor for 2 year construction: 35 x (100%) x 2 years = 70
R-Factor for 0.5 year construction: 35 x (28.4%) = 9.94
R-Factor for complete project duration (2.5 years) = 70 + 9.94 = 79.94

2. ***Find the R value of a construction project in San Diego, California with a duration of June 30, 2012 to November 1, 2013 (1.333 years).***

Figure 1 - Erosivity Index Zone Map:
The EI distribution zone is 25
Table 1 – Erosivity Index Table:
EI percentage June 30 to December 31: 100% – 57.2% = 42.8%
EI percentage January 1 to June 30: 57.2% - 0.0% = 57.2%
Total EI percentage for 1 year duration: 42.8% + 57.2% = 100%
EI percentage June 30 to November 1 (0.333 year): 69.4% - 57.2% = 12.2%
Figure 4 – Isoerodent Map of California:
Interpolated annual erosion index for location: 25

R-Factor for 1 year construction: 25 x (100%) = 25
R-Factor for 0.333 year construction: 25 x (12.2%) = 3.05
R-Factor for complete project duration (1.333 years) = 25 + 3.05 = 28.05

United States Environmental Protection Agency | Office of Water (4203) | EPA 833-F-00-014 Revised March 2012 Fact Sheet 3.1[1]

Stormwater Phase II Final Rule

Construction Rainfall Erosivity Waiver

The 1972 amendments to the Federal Water Pollution Control Act, later referred to as the Clean Water Act (CWA), prohibit the discharge of any pollutant to navigable waters of the United States unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. Because construction site stormwwater runoff can contribute significantly to water quality problems, the Phase I Stormwater Rule imposed a requirement that all construction sites with a planned land disturbance of 5 acres or more obtain an NPDES permit and implement stormwater runoff control plans. Phase II extends the requirements of the stormwater program to sites of between 1 and 5 acres. The Rainfall erosivity waiver allows permitting authorities to waive those sites that do not have adverse water quality impacts.

What is Erosivity?

Erosivity is the term used to describe the potential for soil to wash off disturbed, devegetated earth during storms. The potential for erosion is in part determined by the soil type and geology of the site. For instance, dense, clay-like soils on a glacial plain will erode less readily when it rains than will sandy soils on the side of a hill. Another important factor is the amount and force of precipitation expected during the time the earth will be exposed. While it is impossible to predict the weather several months in advance of construction, for many areas of the country, there are definite optimal periods, such as a dry season when rain tends to fall less frequently and with less force. When feasible, this is the time to disturb the earth, so that the site can be stabilized by the time the seasonal wet weather returns. There are many other important factors to consider in determining erosivity, such as freeze/thaw cycles and snow pack.

How Is Site Erosivity Determined?

The Universal Soil Loss Equation (USLE) was developed by the U.S. Department of Agriculture (USDA) in the 1950s to help farmers conserve their valuable topsoil. The methodology for determining if a site qualifies for the erosivity waiver provided in this guide is based on the *USDA Handbook 703 - Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE)*, dated January 1997. (Note that a more updated version of USLE, the Revised USLE, Version 2 (RUSLE2), is available and can be used as an alternative method for determining if a site qualifies for the erosivity waiver. Information about the RUSLE2 computer program is provided later in this fact sheet.)

Using a computer model supported by decades' worth of soil and rainfall data, USDA established estimates of annual erosivity values (R factors) for sites throughout the country. These R factors are used as surrogate measures of the impact that rainfall had on erosion from a particular site. They have been mapped using isoerodent contours, as shown in Figures 2 through 5.

USDA developed the Erosivity Index Table (EI Table, provided here in Table 1), to show how the annual erosivity factor is distributed throughout the year in two-week increments. Table 1 is based on 120 rainfall distribution zones for the continental U.S. Detailed instructions for calculating a project R factor are provided later in this fact sheet.

[1] This revised fact sheet corrects errors identified in calculating the R factor from the 2001 version, and includes updated information about the USLE.

The Stormwater Phase II rule allows permitting authorities to waive NPDES requirements for small construction sites if the value of the rainfall erosivity factor is less than 5 during the period of construction activity (see § 122.26(b)(15)(i)(A)). Note that the permitting authority has the option to not allow waivers for small construction activity.

If the R factor for the period of construction calculates to less than 5, and the permitting authority allows the use of the waiver, the site owner may apply for a waiver under the low rainfall erosivity provision of the applicable EPA or State NPDES regulations. When applying, owners are encouraged to consider other site-specific factors, such as proximity to water resources and the sensitivity of receiving waters to sedimentation impacts. The small construction operator must certify to the permitting authority that the construction activity will take place during a period when the rainfall erosivity factor is less than 5.

The start and end dates used for the construction activity will be the initial date of disturbance and the anticipated date when the site will have achieved final stabilization as defined by the permit, respectively. If the construction continues beyond this period, the operator will need to recalculate the Erosivity Index for the site based on this new ending date (but keeping the old start date) and either resubmit the certification form or apply for NPDES permit coverage.

What Other Factors Can Affect Waiver Availability and Eligibility?

EPA has established the R factor of less than 5 as the criteria for determining waiver eligibility. However, since the intent is to waive only those construction activities that will not adversely impact water quality, State and Tribal permitting authorities have considerable discretion in determining where, when, and how to offer it. They can establish an R factor threshold lower than 5, or they can suspend the waiver within an area where watersheds are known to be heavily impacted by, or sensitive to, sedimentation. They can also suspend the waiver during certain periods of the year. They may opt not to offer the waiver at all. NOTE: This waiver is not available to sites that will disturb more than 5 acres of land (large construction).

What if My Site Is Not Eligible?

If your site is not eligible for a waiver, you must submit a Notice of Intent, or whichever type of application is required, to obtain coverage under the applicable NPDES construction stormwater permit, and comply with its requirements. For information about EPA's Construction General Permit (CGP), see http://www.epa.gov/npdes/stormwater/cgp. State program information is available at http://cfpub.epa.gov/npdes/contacts.cfm?program_id=6&type=STATE.

Examples

1. Construction started and completed in one calendar year.

Find the R factor value of a construction site in Denver, Colorado. Assume the site will be disturbed from March 10 to May 10 of the same year.

The EI distribution zone is 84 (Figure 1). Referring to Table 1, the project period will span from March 1 (from Table 1, the closest date prior to the actual March 10 start date) to May 15 (from Table 1, the closest date after the actual May 10 end date). The difference in values between these two dates is 9.7% (9.9 - 0.2 = 9.7). Since the annual erosion index for this location is about 45 (interpolated from Figure 2), the R factor for the scheduled construction project is 9.7% of 45, or 4.4.

Because 4.4 is less than 5, the operator of this site would be able to seek a waiver under the low rainfall erosivity provision.

2. Construction spanning two calendar years.

Find the R factor value for a construction site in Pittsburgh, Pennsylvania. Assume the site will be disturbed from August 1 to April 15.

The EI distribution zone is 111 (Figure 1). Referring to Table 1, the project period will span from July 29 (from Table 1, the closest date prior to the actual August 1 start date) to April 15. The difference in values between July 29 and December 31 is 35% (100 - 65.0 = 35.0). The difference between January 1 and April 15 is 8%. The total percentage EI for this project is 43% (35 + 8 = 43). Since the annual erosion index for this location is 112 (interpolated from Figure 2), the R factor for the scheduled construction is 43% of 112, or 48.

Since 48 is greater than 5, the operator of this site would not be able to seek a waiver under the low rainfall erosivity provision.

How Do I Compute the R factor for My Project?

1. Estimate the construction start date. This is the day you expect to begin disturbing soils, including grubbing, stockpiling, excavating, and grading activities.
2. Estimate the day you expect to achieve final stabilization, as defined by your permitting authority's regulations or NPDES construction stormwater permit, over all previous disturbed areas. This is your construction end date.
3. Refer to Figure 1 to find your Erosivity Index (EI) Zone based on your geographic location.

4. Refer to Table 1, the Erosivity Index (EI) Table. Find the number of your EI Zone in the left column. Locate the EI values for the dates that correspond to the project start and end dates you identified in Steps 1 and 2. If your specific date is not on the table, either interpolate between dates to obtain your %EI value, or use the closest date prior to your proposed start date and the closest date after your proposed end date. Subtract the start value from the end value to find the % EI for your site. The maximum annual EI value for a project is 100%. NOTE: If your project lasts for one year or more, your EI value is 100%.
5. Refer to the appropriate Isoerodent Map (Figures 2 through 5). Interpolate the annual isoerodent value for your area. This is the annual R factor for your site.
6. Multiply the percent value obtained in Step 4 by the annual isoerodent value obtained in Step 5. This is the R factor for your scheduled project.

Can I Use a Personal Computer to Calculate the R factor?

The computer program used by USDA to evaluate erosion potential is called the Revised Universal Soil Loss Equation, or RUSLE. The current version of RUSLE (RUSLE2) is a Windows-based model that uses extensive databases that are geographically-linked. RUSLE2 can be used to calculate the R factor for a proposed construction site; however, RUSLE2 can require a large investment of time to set up. RUSLE2 can be downloaded free of charge from the Internet at http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm. Note that RUSLE2 is an upgrade of RUSLE, and contains more detailed data. Therefore, your calculated R factor may differ based on whether you calculate your R factor using the methods specified above, which utilizes data from *USDA Handbook 703 - Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE)*, January 1997, or whether you calculate your R factor using the more updated RUSLE2. EPA notes that either method of calculation is acceptable for determining eligibility for the construction rainfall erosivity waiver.

Where Can I Get Help?

- A copy of "Chapter 2, Rainfall-Runoff Erosivity Factor (R)" from the *USDA Handbook 703 - Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE)*, January 1997, is available on EPA's web site at http://www.epa.gov/npdes/pubs/ruslech2.pdf.
- Information about RUSLE2, and a download of the program, is available at http://fargo.nserl.purdue.edu/rusle2_dataweb/.
- Your local USDA Service Center may be able to provide assistance with calculating R factors and other conservation-related issues. To find the office nearest you, go to http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/contact/local.

For Additional Information

Reference Documents

Stormwater Phase II Final Rule Fact Sheet Series
- Internet: cfpub.epa.gov/npdes/stormwater/swfinal.cfm

Stormwater Phase II Final Rule (64 *FR* 68722)
- Internet: www.epa.gov/npdes/regulations/phase2.pdf
- Contact the U.S. EPA Water Resource Center (Phone: (202) 564-9545)

Agricultural Handbook Number 703, Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE), Chapter 2, pp. 21-64, January 1997.
- Internet: www.epa.gov/npdes/pubs/ruslech2.pdf

Figure 1. Erosivity Index Zone Map

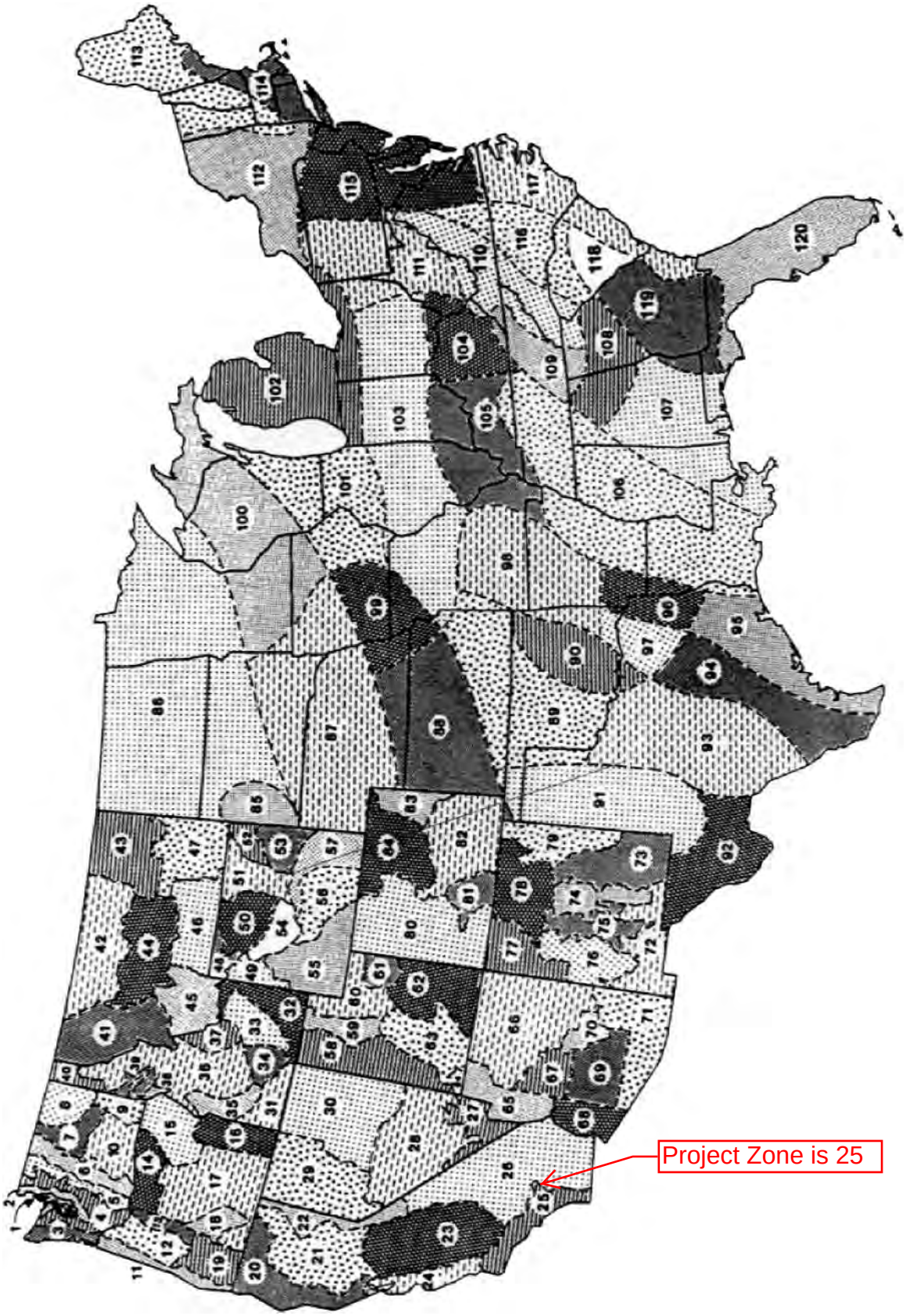
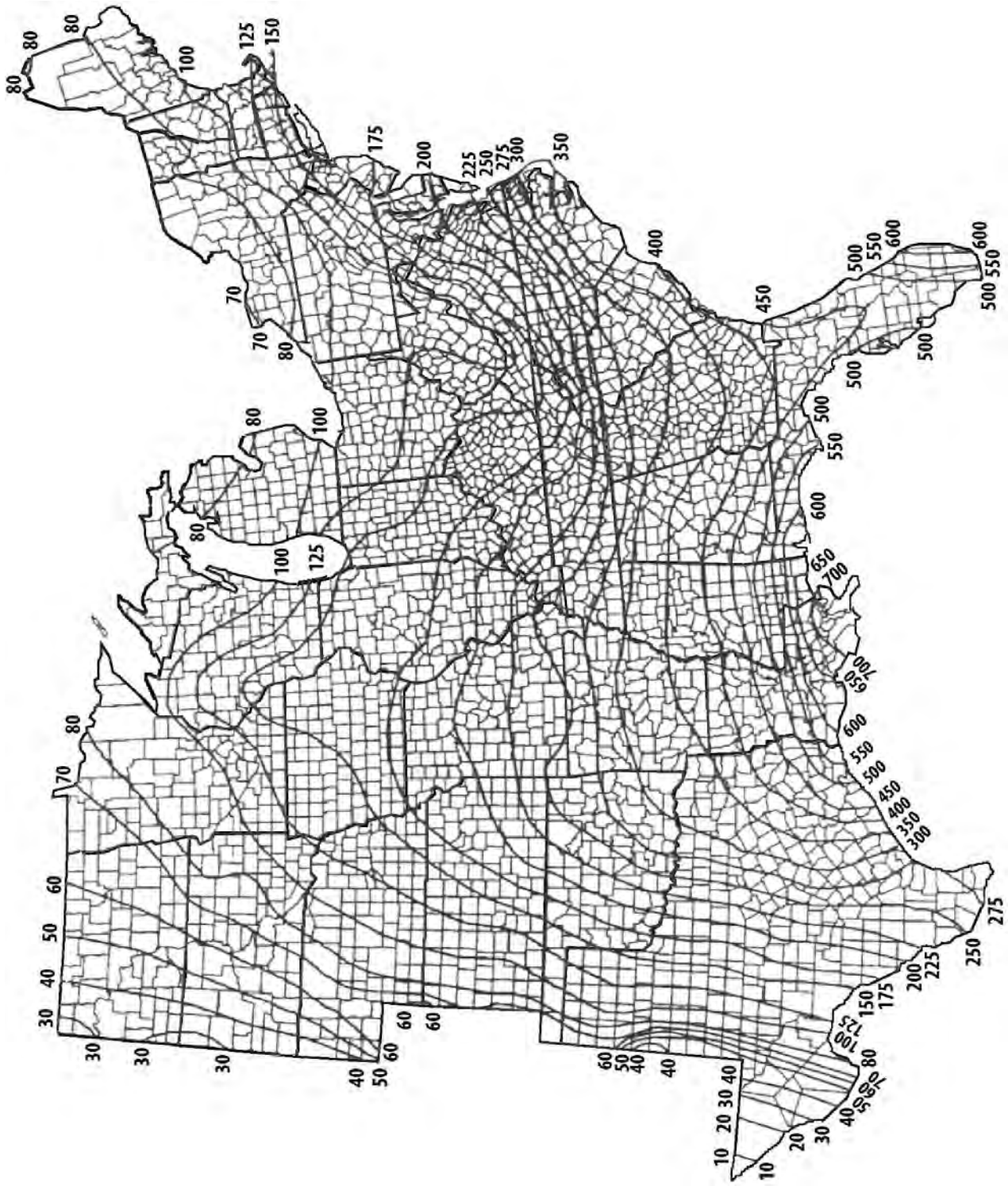


Figure 2. Isoerodent Map of the Eastern U.S.

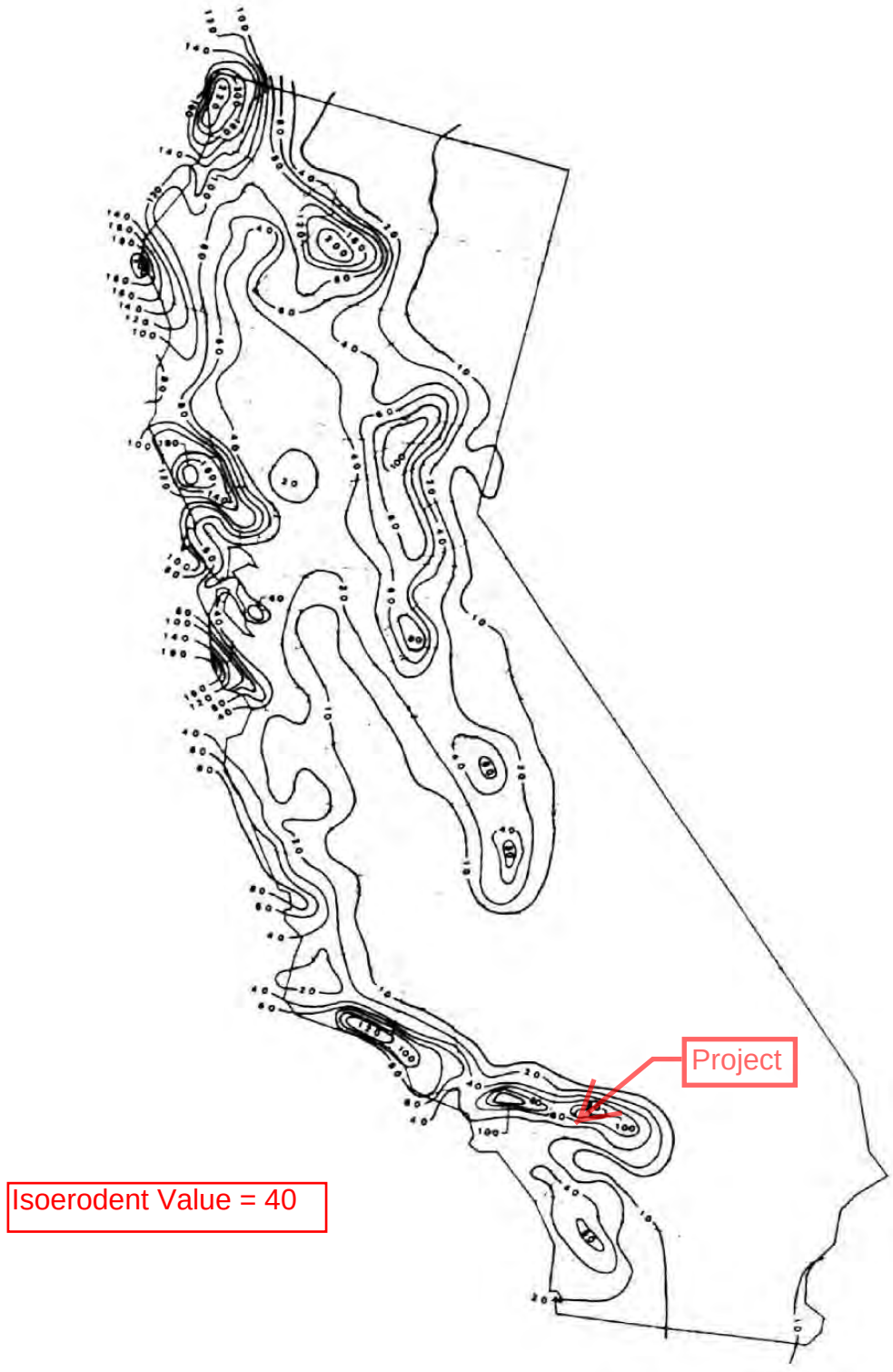


Note: Units for all maps on this page are hundreds ft•tonf•in(ac•h•yr)$^{-1}$

Figure 3. Isoerodent Map of the Western U.S.

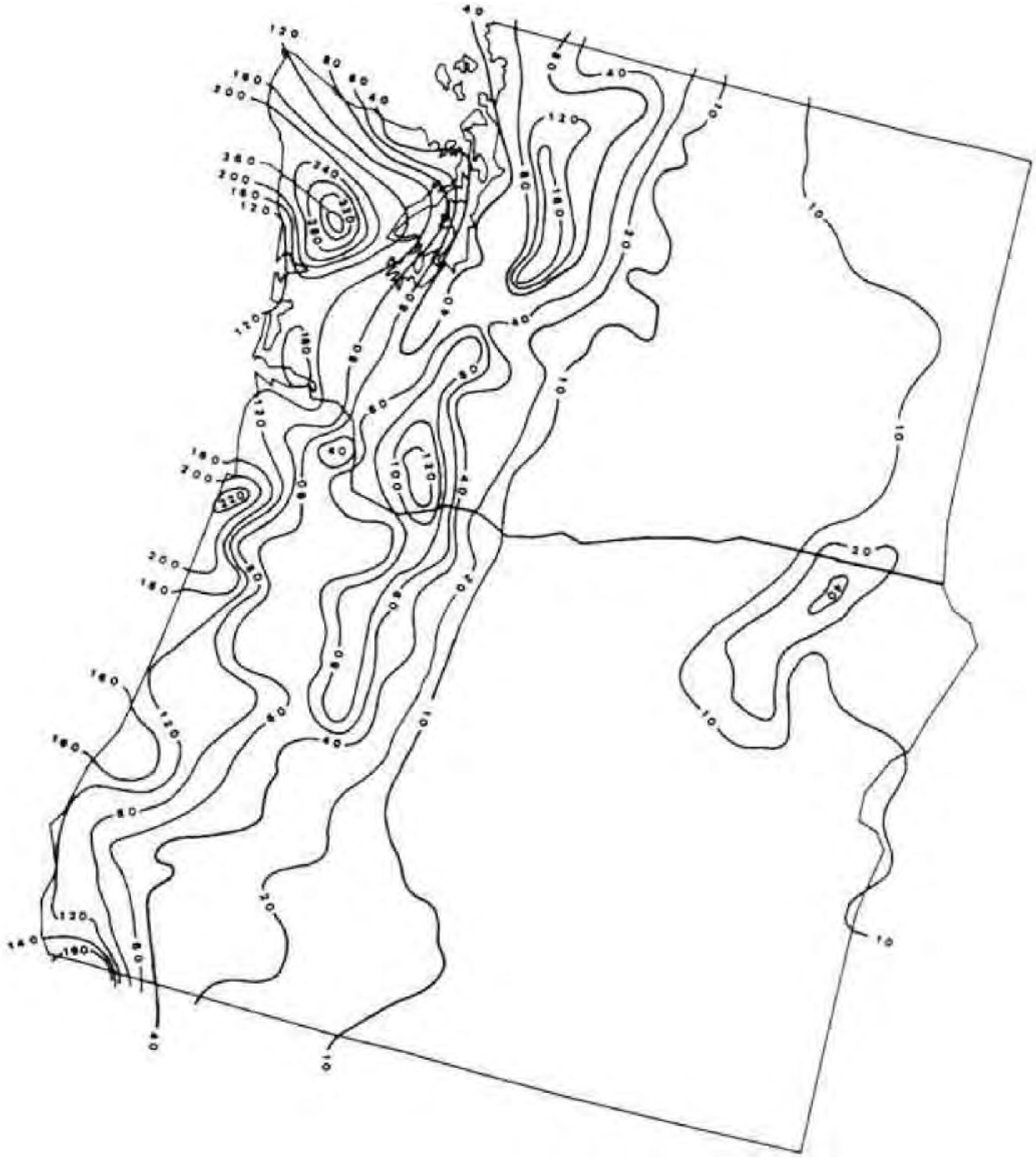
Note: Units for all maps on this page are hundreds ft•tonf•in(ac•h•yr)$^{-1}$

Figure 4. Isoerodent Map of California



Note: Units for all maps on this page are hundreds ft•tonf•in(ac•h•yr)$^{-1}$

Figure 5. Isoerodent Map of Oregon and Washington



Note: Units for all maps on this page are hundreds ft•tonf•in(ac•h•yr)$^{-1}$

Table 1. Erosivity Index (%EI Values extracted from USDA Manual 703)

All values are at the end of the day listed below - Linear interpolation between dates is acceptable.
EI as a percentage of Average Annual R Value Computed for Geographic Areas Shown in Figure 1

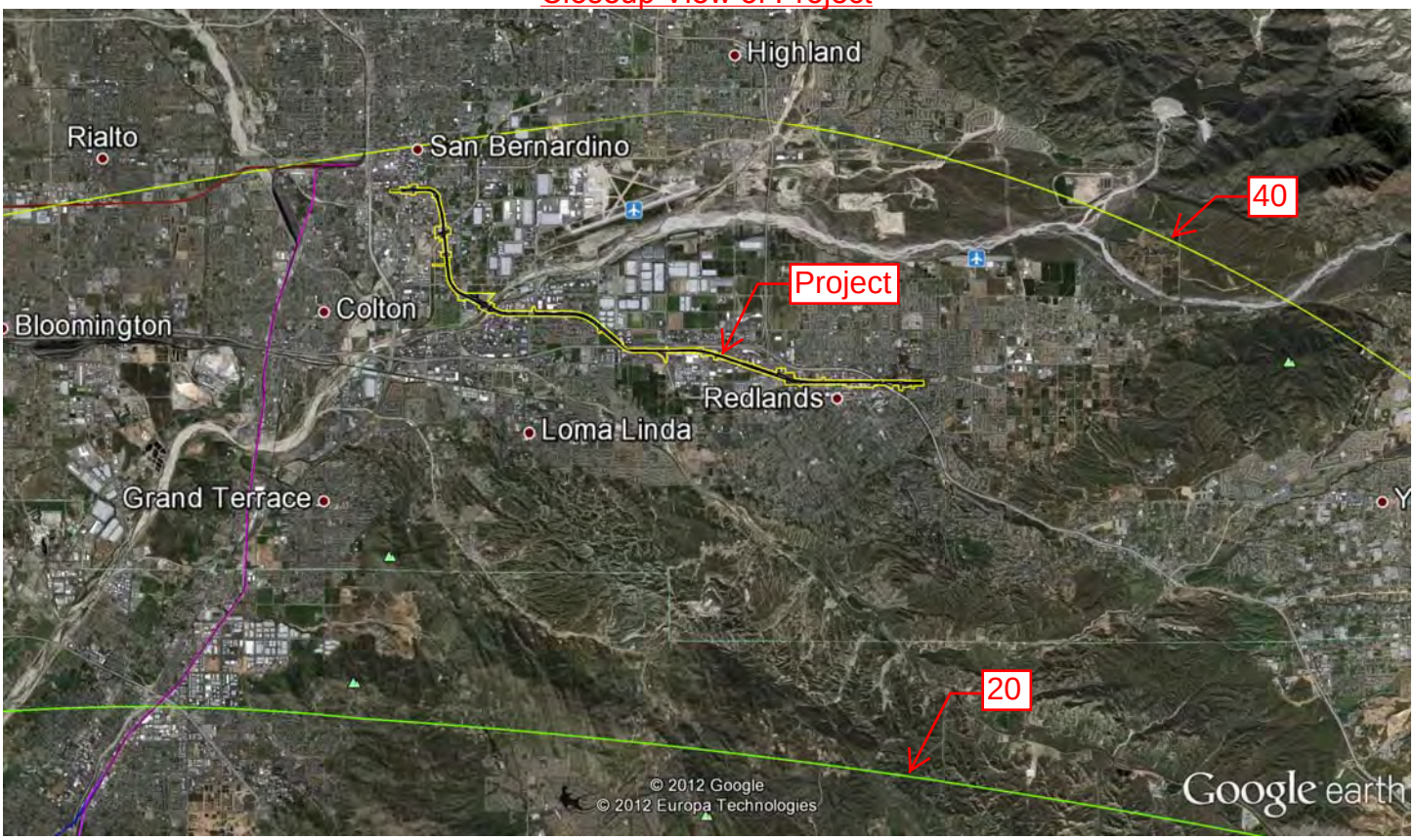
Month	Jan	Jan	Jan	Feb	Mar	Mar	Mar	Apr	Apr	May	May	Jun	Jun	Jul	Jul	Aug	Aug	Sept	Sept	Oct	Oct	Nov	Nov	Dec	Dec
Day	1	16	31	15	1	16	31	15	30	15	30	14	29	14	29	13	28	12	27	12	27	11	26	11	31
EI Zone																									
1	0	4.3	8.3	12.8	17.3	21.6	25.1	28	30.9	34.9	39.1	42.6	45.4	48.2	50.8	53	56	60.8	66.8	71	75.7	82	89.1	95.2	100
2	0	4.3	8.3	12.8	17.3	21.6	25.1	28.0	30.9	34.9	39.1	42.6	45.4	48.2	50.8	53.0	56.0	60.8	66.8	71.0	75.7	82.0	89.1	95.2	100
3	0	7.4	13.8	20.9	26.5	31.8	35.3	38.5	40.2	41.6	42.5	43.6	44.5	45.1	45.7	46.4	47.7	49.4	52.8	57.0	64.5	73.1	83.3	92.3	100
4	0	3.9	7.9	12.6	17.4	21.6	25.2	28.7	31.9	35.1	38.2	42.0	44.9	46.7	48.2	50.1	53.1	56.6	62.2	67.9	75.2	83.5	90.5	96.0	100
5	0	2.3	3.6	4.7	6.0	7.7	10.7	13.9	17.8	21.2	24.5	28.1	31.1	33.1	35.3	38.2	43.2	48.7	57.3	67.8	77.9	86.0	91.3	96.9	100
6	0	0.0	0.0	0.5	2.0	4.1	8.1	12.6	17.6	21.6	25.5	29.6	34.5	40.0	45.7	50.7	55.6	60.2	66.5	75.5	85.6	95.9	99.5	99.9	100
7	0	0.0	0.0	0.0	0.0	1.2	4.9	8.5	13.9	19.0	26.0	35.4	43.9	48.8	53.9	64.5	73.4	77.5	80.4	84.8	89.9	96.6	99.2	99.7	100
8	0	0.0	0.0	0.0	0.0	0.9	3.6	7.8	15.0	20.2	27.4	38.1	49.8	57.9	65.0	75.6	82.7	86.8	89.4	93.4	96.3	99.1	100.0	100.0	100
9	0	0.8	3.1	4.7	7.4	11.7	17.8	22.5	27.0	31.4	36.0	41.6	46.4	50.1	53.4	57.4	61.7	64.9	69.7	79.0	89.6	97.4	100.0	100.0	100
10	0	0.3	0.5	0.9	2.0	4.3	9.2	13.1	18.0	22.7	29.2	39.5	46.3	48.8	51.1	57.2	64.4	67.7	71.1	77.2	85.1	92.5	96.5	99.0	100
11	0	5.4	11.3	18.8	26.3	33.2	37.4	40.7	42.5	44.3	45.4	46.5	47.1	47.4	47.8	48.3	49.4	50.7	53.6	57.5	65.5	76.2	87.4	94.8	100
12	0	3.5	7.8	14.0	21.1	27.4	31.5	35.0	37.3	39.8	41.9	44.3	45.6	46.3	46.8	47.9	50.0	52.9	57.9	62.3	69.3	81.3	91.5	96.7	100
13	0	0.0	0.0	1.8	7.2	11.9	16.7	19.7	24.0	31.2	42.4	55.0	60.0	60.8	61.2	62.6	65.3	67.6	71.6	76.1	83.1	93.3	98.2	99.6	100
14	0	0.7	1.8	3.3	6.9	16.5	26.6	29.9	32.0	35.4	40.2	45.1	51.9	61.1	67.5	70.7	72.8	75.4	78.6	81.9	86.4	93.6	97.7	99.3	100
15	0	0.0	0.0	0.5	2.0	4.4	8.7	12.0	16.6	21.4	29.7	44.5	56.0	60.8	63.9	69.1	74.5	79.1	83.1	87.0	90.9	96.6	99.1	99.8	100
16	0	0.0	0.0	0.5	2.0	5.5	12.3	16.2	20.9	26.4	35.2	48.1	58.1	63.1	66.5	71.9	77.0	81.6	85.1	88.4	91.5	96.3	98.7	99.6	100
17	0	0.0	0.0	0.7	2.8	6.1	10.7	12.9	16.1	21.9	32.8	45.9	55.5	60.3	64.0	71.2	77.2	80.3	83.1	87.7	92.6	97.2	99.1	99.8	100
18	0	0.0	0.0	0.6	2.5	6.2	12.4	16.4	20.2	23.9	29.3	37.7	45.6	49.8	53.3	58.4	64.3	69.0	75.0	86.6	93.9	96.6	98.0	100.0	100
19	0	1.0	2.6	7.4	16.4	23.5	28.0	31.0	33.5	37.0	41.7	48.1	51.1	52.0	52.5	53.6	55.7	57.6	61.1	65.8	74.7	88.0	95.8	98.7	100
20	0	9.8	18.5	25.4	30.2	35.6	38.9	41.5	42.9	44.0	45.2	48.2	50.8	51.7	52.5	54.6	57.4	58.5	60.1	63.2	69.6	76.7	85.4	92.4	100
21	0	7.5	13.6	18.1	21.1	24.4	27.0	29.4	31.7	34.6	37.3	39.6	41.6	43.4	45.4	48.1	51.3	53.3	56.6	62.4	72.4	81.3	88.9	94.7	100
22	0	1.2	1.6	1.6	1.6	1.6	1.6	2.2	3.9	4.6	6.4	14.2	32.8	47.2	58.8	69.1	76.0	82.0	87.1	96.7	99.9	99.9	99.9	99.9	100
23	0	7.9	15.0	20.9	25.7	31.1	35.7	40.2	43.2	46.2	47.7	48.8	49.4	49.9	50.7	51.8	54.1	57.7	62.8	65.9	70.1	77.3	86.8	93.5	100
24	0	12.2	23.6	33.0	39.7	47.1	51.7	55.9	57.7	58.6	58.9	59.1	59.1	59.2	59.2	59.3	59.5	60.0	61.4	63.0	66.5	71.8	81.3	89.6	100
25	0	9.8	20.8	30.2	37.6	45.8	50.6	54.4	56.0	56.8	57.1	57.1	57.2	57.6	58.5	59.8	62.2	65.3	67.5	68.2	69.4	74.8	86.6	93.0	100
26	0	2.0	5.4	9.8	15.6	21.5	24.7	26.6	27.4	28.0	28.7	29.8	32.5	36.6	44.9	55.4	65.7	72.6	77.8	84.4	89.5	93.9	96.5	98.4	100
27	0	0.0	0.0	1.0	4.0	5.9	8.0	11.1	13.0	14.0	14.6	15.3	17.0	23.2	39.1	60.0	76.3	86.1	89.7	90.4	90.9	93.1	96.6	99.1	100
28	0	0.0	0.0	0.0	0.2	0.5	1.5	3.3	7.2	11.9	17.7	21.4	27.0	37.1	51.4	62.3	70.6	78.8	84.6	90.6	94.4	97.9	99.3	100.0	100
29	0	0.6	0.7	0.7	0.7	1.5	3.9	6.0	10.5	17.9	28.8	36.6	43.8	51.5	59.3	68.0	74.8	80.3	84.3	88.8	92.7	98.0	99.8	99.9	100
30	0	0.0	0.0	0.0	0.0	0.2	0.8	2.8	7.9	14.2	24.7	35.6	45.4	52.2	58.7	68.5	77.6	84.5	88.9	93.7	96.2	97.6	98.3	99.6	100
31	0	0.0	0.0	0.0	0.0	0.2	1.0	3.5	9.9	15.7	26.4	47.2	61.4	65.9	69.0	77.2	86.0	91.6	94.8	98.7	100.0	100.0	100.0	100.0	100
32	0	0.1	0.1	0.1	0.1	0.6	2.2	4.3	9.0	14.2	23.3	34.6	46.3	54.2	61.7	72.9	82.5	89.6	93.7	98.2	99.7	99.9	99.9	99.9	100
33	0	0.0	0.0	0.0	0.0	0.6	2.3	4.2	8.8	16.1	30.0	46.9	57.9	62.8	66.2	72.1	79.1	85.9	91.1	97.0	98.9	98.9	98.9	98.9	100
34	0	0.0	0.0	0.0	0.0	1.8	7.3	10.7	15.5	22.0	29.9	35.9	42.0	48.5	56.9	67.0	76.9	85.8	91.2	95.7	97.8	99.6	100.0	100.0	100
35	0	0.0	0.0	0.0	0.0	2.5	10.2	15.9	22.2	27.9	34.7	43.9	51.9	56.9	61.3	67.3	73.9	80.1	85.1	89.6	93.2	98.2	99.8	99.8	100

Month	Jan	Jan	Jan	Feb	Mar	Mar	Mar	Apr	Apr	May	May	Jun	Jun	Jul	Jul	Aug	Aug	Sept	Sept	Oct	Oct	Nov	Nov	Dec	Dec
Day	1	16	31	15	1	16	31	15	30	15	30	14	29	14	29	13	28	12	27	12	27	11	26	11	31
EI Zone																									
36	0	0.0	0.0	0.0	0.0	0.9	3.4	6.7	12.7	18.5	26.6	36.3	46.0	53.5	60.2	68.3	75.8	82.6	88.3	96.3	99.3	99.9	100.0	100.0	100
37	0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.9	9.1	19.1	26.7	36.3	47.9	61.4	75.1	84.5	92.3	96.0	99.1	100.0	100.0	100.0	100.0	100
38	0	0.0	0.0	1.1	4.3	7.2	11.0	13.9	17.9	22.3	30.3	43.1	55.1	61.3	65.7	72.1	77.9	82.6	86.3	90.3	93.8	98.4	100.0	100.0	100
39	0	0.0	0.0	0.0	0.0	1.6	6.5	11.0	17.8	24.7	33.1	42.8	50.3	54.9	59.7	68.9	78.1	83.6	87.5	93.0	96.5	99.2	100.0	100.0	100
40	0	0.0	0.0	0.0	0.0	1.5	6.2	10.1	16.3	23.3	32.5	42.2	50.1	55.6	60.5	67.5	74.3	79.4	84.1	91.1	95.8	99.1	100.0	100.0	100
41	0	0.1	0.2	0.2	0.2	0.2	0.2	0.4	1.1	6.8	22.9	40.1	54.9	63.8	70.7	81.5	89.8	96.3	98.7	99.2	99.3	99.4	99.4	99.7	100
42	0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.9	5.2	17.3	33.8	53.2	66.5	75.9	87.6	93.7	97.5	99.0	99.7	100.0	100.0	100.0	100.0	100
43	0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	2.7	9.5	21.9	42.7	58.6	71.1	84.6	91.9	97.1	99.0	99.8	100.0	100.0	100.0	100.0	100
44	0	1.7	2.3	2.4	2.4	2.4	2.4	2.7	3.5	7.6	18.5	34.3	52.5	64.0	72.3	83.3	90.0	95.1	97.3	98.5	98.9	98.9	98.9	99.2	100
45	0	0.2	0.2	0.3	0.3	0.4	0.6	0.8	1.4	3.7	10.2	22.6	41.8	54.0	64.5	78.7	88.4	96.0	98.7	99.4	99.7	99.7	99.8	99.9	100
46	0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	2.6	7.5	19.6	32.9	48.9	63.0	73.5	83.3	89.5	95.6	98.3	99.6	100.0	100.0	100.0	100.0	100
47	0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.6	5.8	17.0	33.0	52.5	66.4	75.7	85.5	91.3	96.5	98.8	100.0	100.0	100.0	100.0	100.0	100
48	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	8.1	15.4	27.8	40.7	52.6	61.1	69.3	82.6	92.0	98.0	100.0	100.0	100.0	100.0	100
49	0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	2.7	8.3	20.0	27.5	35.6	44.6	46.0	70.2	81.3	89.2	93.6	98.5	100.0	100.0	100.0	100.0	100
50	0	0.0	0.0	0.0	0.0	0.1	0.4	2.4	8.2	13.7	23.8	38.8	55.1	66.1	73.6	81.8	87.7	93.8	97.0	99.4	100.0	100.0	100.0	100.0	100
51	0	0.0	0.0	0.0	0.0	0.3	1.0	3.1	8.7	18.8	35.8	49.6	60.4	70.2	77.0	84.0	88.8	93.8	96.6	99.1	100.0	100.0	100.0	100.0	100
52	0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	2.5	6.8	17.5	29.8	46.1	60.5	72.7	86.0	92.8	96.8	98.4	99.7	100.0	100.0	100.0	100.0	100
53	0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	3.0	9.5	24.2	35.3	48.0	63.1	76.1	87.7	93.5	97.2	98.6	99.5	99.8	99.9	100.0	100.0	100
54	0	0.0	0.0	0.0	0.0	0.2	0.7	2.4	7.2	14.7	27.2	37.2	47.3	58.8	67.6	74.0	79.2	86.7	92.6	97.9	99.8	99.9	100.0	100.0	100
55	0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	5.4	13.3	25.5	31.6	38.8	52.5	66.8	75.5	81.2	87.9	92.8	98.3	100.0	100.0	100.0	100.0	100
56	0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	5.1	11.4	22.3	29.5	38.5	51.1	65.2	77.8	85.6	91.7	95.0	98.7	100.0	100.0	100.0	100.0	100
57	0	0.0	0.0	0.0	0.0	0.0	0.1	1.0	3.5	9.2	21.5	31.0	43.5	60.4	75.1	86.1	91.6	96.2	98.1	99.4	99.9	99.9	100.0	100.0	100
58	0	0.0	0.0	0.0	0.0	0.2	0.9	2.9	8.0	13.2	21.0	29.1	38.0	45.9	54.5	65.4	74.8	82.1	87.5	95.4	98.8	99.7	100.0	100.0	100
59	0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	8.9	15.6	24.2	31.1	38.3	46.0	54.9	64.2	73.2	81.9	88.5	95.7	98.6	99.4	99.7	99.7	100
60	0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.5	4.0	9.5	13.3	20.5	33.6	52.8	66.5	76.7	88.1	94.2	98.6	100.0	100.0	100.0	100.0	100
61	0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	5.0	8.5	15.5	29.8	41.8	46.0	49.2	56.0	65.1	71.6	78.6	91.1	97.3	99.3	100.0	100.0	100
62	0	0.0	0.0	0.1	0.3	0.8	2.1	3.6	6.5	9.7	13.7	16.5	20.8	27.3	40.1	56.9	72.6	83.4	89.4	95.5	98.1	99.6	100.0	100.0	100
63	0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	3.7	7.8	13.3	15.8	19.9	29.0	46.8	64.7	78.3	88.8	93.9	98.5	100.0	100.0	100.0	100.0	100
64	0	0.0	0.0	0.7	2.8	7.4	12.4	14.4	15.6	17.3	19.4	21.0	24.4	32.3	48.0	61.4	72.1	81.9	87.0	90.1	92.4	98.1	100.0	100.0	100
65	0	3.6	7.0	9.6	11.4	13.0	14.4	16.3	17.7	18.4	19.3	20.5	23.6	32.0	50.0	66.2	77.2	85.4	88.8	90.4	91.3	92.7	94.8	97.0	100
66	0	0.0	0.0	0.0	0.0	0.1	0.5	1.1	2.2	3.6	6.0	7.6	11.1	19.8	38.9	59.7	74.4	83.2	88.1	94.6	97.7	99.4	100.0	100.0	100
67	0	0.0	0.0	0.0	0.0	0.1	0.4	0.9	1.6	1.9	2.4	5.0	12.1	24.8	48.3	73.6	86.5	92.0	94.3	96.6	97.9	99.5	100.0	100.0	100
68	0	2.3	4.5	7.8	10.4	12.0	13.3	16.3	17.7	18.1	18.2	18.3	18.4	19.9	24.5	35.0	54.4	69.4	78.6	85.7	89.2	91.9	93.9	97.0	100
69	0	2.0	3.7	5.7	7.8	10.5	12.4	13.7	14.3	14.7	15.1	15.7	17.1	22.7	36.7	50.4	63.6	75.0	81.8	87.8	90.8	93.2	94.9	97.5	100
70	0	0.5	0.7	1.0	1.3	1.7	2.2	2.8	3.4	3.9	4.7	5.4	7.4	15.7	36.5	55.8	70.3	80.9	86.4	90.9	93.4	96.4	98.1	99.4	100
71	0	0.7	1.2	1.6	2.1	2.8	3.3	3.6	4.0	4.5	5.6	6.5	9.1	18.5	40.6	59.7	74.0	86.3	91.7	94.7	96.0	96.7	97.3	98.8	100
72	0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.7	0.8	1.3	3.5	9.9	24.7	51.4	71.5	83.6	93.8	97.7	99.2	99.8	99.9	99.9	100.0	100
73	0	0.0	0.1	0.1	0.2	0.2	0.3	0.6	1.3	4.1	11.5	18.1	28.3	40.2	54.1	67.0	77.2	87.7	93.3	97.5	99.1	99.6	99.8	100.0	100
74	0	0.0	0.0	0.0	0.0	0.1	0.2	0.5	1.2	2.7	6.4	10.2	18.4	31.0	50.7	68.7	81.2	91.6	96.1	98.4	99.2	99.8	100.0	100.0	100
75	0	0.1	0.1	0.1	0.2	0.5	1.3	1.9	3.0	4.1	6.6	10.0	17.6	28.3	44.7	59.4	71.6	83.9	90.3	94.7	96.7	98.8	99.6	99.9	100

Month	Jan	Jan	Jan	Feb	Mar	Mar	Mar	Apr	Apr	May	May	Jun	Jun	Jul	Jul	Aug	Aug	Sept	Sept	Oct	Oct	Nov	Nov	Dec	Dec
Day	1	16	31	15	1	16	31	15	30	15	30	14	29	14	29	13	28	12	27	12	27	11	26	11	31
EI Zone																									
76	0	0.0	0.0	0.0	0.0	0.1	0.2	0.6	1.3	2.0	3.5	4.9	8.4	17.4	37.3	57.5	72.9	83.7	89.5	95.8	98.4	99.6	100.0	100.0	100
77	0	0.2	0.3	0.3	0.4	0.8	1.5	2.0	2.8	3.9	5.9	7.2	10.3	21.5	46.5	66.3	78.3	86.5	90.8	96.0	98.2	99.1	99.5	99.8	100
78	0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	1.6	3.8	8.9	13.2	21.8	35.8	56.6	75.4	86.0	92.9	95.9	98.2	99.2	99.8	100.0	100.0	100
79	0	0.0	0.0	0.0	0.0	0.2	0.7	1.3	2.7	5.8	12.7	18.8	28.8	41.6	58.4	75.7	86.5	94.2	97.3	98.9	99.5	99.9	100.0	100.0	100
80	0	0.6	1.2	1.6	2.1	2.5	3.3	4.5	6.9	10.1	15.5	19.7	26.6	36.4	51.7	67.5	79.4	88.8	93.2	96.1	97.3	98.2	98.7	99.3	100
81	0	0.1	0.1	0.2	0.4	0.5	0.8	0.9	1.5	3.9	9.9	12.8	18.2	30.7	54.1	77.1	89.0	94.9	97.2	98.7	99.3	99.6	99.7	99.9	100
82	0	0.0	0.1	0.1	0.2	0.2	0.5	1.2	3.1	6.7	14.4	20.1	29.8	44.5	64.2	83.1	92.2	96.4	98.1	99.3	99.7	99.8	99.8	99.9	100
83	0	0.0	0.1	0.1	0.1	0.3	0.9	1.6	3.5	8.3	19.4	30.0	44.0	59.2	72.4	84.6	91.2	96.5	98.6	99.5	99.8	99.9	100.0	100.0	100
84	0	0.0	0.1	0.1	0.2	0.3	0.6	1.7	4.9	9.9	19.5	27.2	38.3	52.8	68.8	83.9	91.6	96.4	98.2	99.2	99.6	99.8	99.8	99.9	100
85	0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	3.0	6.0	11.0	23.0	36.0	49.0	63.0	77.0	90.0	95.0	98.0	99.0	100.0	100.0	100.0	100.0	100
86	0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	3.0	6.0	11.0	23.0	36.0	49.0	63.0	77.0	90.0	95.0	98.0	99.0	100.0	100.0	100.0	100.0	100
87	0	0.0	0.0	0.0	1.0	1.0	2.0	3.0	6.0	10.0	17.0	29.0	43.0	55.0	67.0	77.0	85.0	91.0	96.0	98.0	99.0	100.0	100.0	100.0	100
88	0	0.0	0.0	0.0	1.0	1.0	2.0	3.0	6.0	13.0	23.0	37.0	51.0	61.0	69.0	78.0	85.0	91.0	94.0	96.0	98.0	99.0	99.0	100.0	100
89	0	1.0	1.0	2.0	3.0	4.0	7.0	12.0	18.0	27.0	38.0	48.0	55.0	62.0	69.0	76.0	83.0	90.0	94.0	97.0	98.0	99.0	100.0	100.0	100
90	0	1.0	2.0	3.0	4.0	6.0	8.0	13.0	21.0	29.0	37.0	46.0	54.0	60.0	65.0	69.0	74.0	81.0	87.0	92.0	95.0	97.0	98.0	99.0	100
91	0	0.0	0.0	0.0	1.0	1.0	1.0	2.0	6.0	16.0	29.0	39.0	46.0	53.0	60.0	67.0	74.0	81.0	88.0	95.0	99.0	99.0	100.0	100.0	100
92	0	0.0	0.0	0.0	1.0	1.0	1.0	2.0	6.0	16.0	29.0	39.0	46.0	53.0	60.0	67.0	74.0	81.0	88.0	95.0	99.0	99.0	100.0	100.0	100
93	0	1.0	1.0	2.0	3.0	4.0	6.0	8.0	13.0	25.0	40.0	49.0	56.0	62.0	67.0	72.0	76.0	80.0	85.0	91.0	97.0	98.0	99.0	99.0	100
94	0	1.0	2.0	4.0	6.0	8.0	10.0	15.0	21.0	29.0	38.0	47.0	53.0	57.0	61.0	65.0	70.0	76.0	83.0	88.0	91.0	94.0	96.0	98.0	100
95	0	1.0	3.0	5.0	7.0	9.0	11.0	14.0	18.0	27.0	35.0	41.0	46.0	51.0	57.0	62.0	68.0	73.0	79.0	84.0	89.0	93.0	96.0	98.0	100
96	0	2.0	4.0	6.0	9.0	12.0	17.0	23.0	30.0	37.0	43.0	49.0	54.0	58.0	62.0	66.0	70.0	74.0	78.0	82.0	86.0	90.0	94.0	97.0	100
97	0	1.0	3.0	5.0	7.0	10.0	14.0	20.0	28.0	37.0	48.0	56.0	61.0	64.0	68.0	72.0	77.0	81.0	86.0	89.0	92.0	95.0	98.0	99.0	100
98	0	1.0	2.0	4.0	6.0	8.0	10.0	13.0	19.0	26.0	34.0	42.0	50.0	58.0	63.0	68.0	74.0	79.0	84.0	89.0	93.0	95.0	97.0	99.0	100
99	0	0.0	0.0	1.0	1.0	2.0	3.0	5.0	7.0	12.0	19.0	33.0	48.0	57.0	65.0	72.0	82.0	88.0	93.0	96.0	98.0	99.0	100.0	100.0	100
100	0	0.0	0.0	0.0	1.0	1.0	2.0	3.0	5.0	9.0	15.0	27.0	38.0	50.0	62.0	74.0	84.0	91.0	95.0	97.0	98.0	99.0	99.0	100.0	100
101	0	0.0	0.0	1.0	2.0	3.0	4.0	6.0	9.0	14.0	20.0	28.0	39.0	52.0	63.0	72.0	80.0	87.0	91.0	94.0	97.0	98.0	99.0	100.0	100
102	0	0.0	1.0	2.0	3.0	4.0	6.0	8.0	11.0	15.0	22.0	31.0	40.0	49.0	59.0	69.0	78.0	85.0	91.0	94.0	96.0	98.0	99.0	100.0	100
103	0	1.0	2.0	3.0	4.0	6.0	8.0	10.0	14.0	18.0	25.0	34.0	45.0	56.0	64.0	72.0	79.0	84.0	89.0	92.0	95.0	97.0	98.0	99.0	100
104	0	2.0	3.0	5.0	7.0	10.0	13.0	16.0	19.0	23.0	27.0	34.0	44.0	54.0	63.0	72.0	80.0	85.0	89.0	91.0	93.0	95.0	96.0	98.0	100
105	0	1.0	3.0	6.0	9.0	12.0	16.0	21.0	26.0	31.0	37.0	43.0	50.0	57.0	64.0	71.0	77.0	81.0	85.0	88.0	91.0	93.0	95.0	97.0	100
106	0	3.0	6.0	9.0	13.0	17.0	21.0	27.0	33.0	38.0	44.0	49.0	55.0	61.0	67.0	71.0	75.0	78.0	81.0	84.0	86.0	90.0	94.0	97.0	100
107	0	3.0	5.0	7.0	10.0	14.0	18.0	23.0	27.0	31.0	35.0	39.0	45.0	53.0	60.0	67.0	74.0	80.0	84.0	86.0	88.0	90.0	93.0	95.0	100
108	0	3.0	6.0	9.0	12.0	16.0	20.0	24.0	28.0	33.0	38.0	43.0	50.0	59.0	69.0	75.0	80.0	84.0	87.0	90.0	92.0	94.0	96.0	98.0	100
109	0	3.0	6.0	10.0	13.0	16.0	19.0	23.0	26.0	29.0	33.0	39.0	47.0	58.0	68.0	75.0	80.0	83.0	86.0	88.0	90.0	92.0	95.0	97.0	100
110	0	1.0	3.0	5.0	7.0	9.0	12.0	15.0	18.0	21.0	25.0	29.0	36.0	45.0	56.0	68.0	77.0	83.0	88.0	91.0	93.0	95.0	97.0	99.0	100
111	0	1.0	2.0	3.0	4.0	5.0	6.0	8.0	11.0	15.0	20.0	28.0	41.0	54.0	65.0	74.0	82.0	87.0	92.0	94.0	96.0	97.0	98.0	99.0	100
112	0	0.0	0.0	1.0	2.0	3.0	4.0	5.0	7.0	12.0	17.0	24.0	33.0	42.0	55.0	67.0	76.0	83.0	89.0	92.0	94.0	96.0	98.0	99.0	100
113	0	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	13.0	17.0	22.0	31.0	42.0	52.0	60.0	68.0	75.0	80.0	85.0	89.0	92.0	96.0	98.0	100
114	0	1.0	2.0	4.0	6.0	8.0	11.0	13.0	15.0	18.0	21.0	26.0	32.0	38.0	46.0	55.0	64.0	71.0	77.0	81.0	85.0	89.0	93.0	97.0	100
115	0	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	14.0	19.0	26.0	34.0	45.0	56.0	66.0	76.0	82.0	86.0	90.0	93.0	95.0	97.0	99.0	100

Month	Jan	Jan	Jan	Feb	Mar	Mar	Mar	Apr	Apr	May	May	Jun	Jun	Jul	Jul	Aug	Aug	Sept	Sept	Oct	Oct	Nov	Nov	Dec	Dec
Day	1	16	31	15	1	16	31	15	30	15	30	14	29	14	29	13	28	12	27	12	27	11	26	11	31
El Zone																									
116	0	1.0	3.0	5.0	7.0	9.0	12.0	15.0	18.0	21.0	25.0	29.0	36.0	45.0	56.0	68.0	77.0	83.0	88.0	91.0	93.0	95.0	97.0	99.0	100
117	0	1.0	2.0	3.0	4.0	5.0	7.0	9.0	11.0	14.0	17.0	22.0	31.0	42.0	54.0	65.0	74.0	83.0	89.0	92.0	95.0	97.0	98.0	99.0	100
118	0	1.0	2.0	3.0	5.0	7.0	10.0	14.0	18.0	22.0	27.0	32.0	37.0	46.0	58.0	69.0	80.0	89.0	93.0	94.0	95.0	96.0	97.0	97.0	100
119	0	2.0	4.0	6.0	8.0	12.0	16.0	20.0	25.0	30.0	35.0	41.0	47.0	56.0	67.0	75.0	81.0	85.0	87.0	89.0	91.0	93.0	95.0	97.0	100
120	0	1.0	2.0	4.0	6.0	7.0	9.0	12.0	15.0	18.0	23.0	31.0	40.0	48.0	57.0	63.0	72.0	78.0	88.0	92.0	96.0	97.0	98.0	99.0	100
121	0	8.0	16.0	25.0	33.0	41.0	46.0	50.0	53.0	54.0	55.0	56.0	56.5	57.0	57.8	58.0	58.8	60.0	61.0	63.0	66.5	72.0	80.0	90.0	100
122	0	7.0	14.0	20.0	25.5	33.5	38.0	43.0	46.0	50.0	52.5	54.5	56.0	58.0	59.0	60.0	61.5	63.0	65.0	68.0	72.0	79.0	86.0	93.0	100
123	0	4.0	8.0	12.0	17.0	23.0	29.0	34.0	38.0	44.0	49.0	53.0	56.0	59.0	62.0	65.0	69.0	72.0	75.0	79.0	83.0	88.0	93.0	96.0	100
124	0	4.0	9.0	15.0	23.0	29.0	34.0	40.0	44.0	48.0	50.0	51.0	52.0	53.0	55.0	57.0	60.0	62.0	64.0	67.0	72.0	80.0	88.0	95.0	100
125	0	7.0	12.0	17.0	24.0	30.0	39.0	45.0	50.0	53.0	55.0	56.0	57.0	58.0	59.0	61.0	62.0	63.0	64.0	66.0	70.0	77.0	84.0	92.0	100
126	0	9.0	16.0	23.0	30.0	37.0	43.0	47.0	50.0	52.0	54.0	55.0	56.0	57.0	58.0	59.0	60.0	62.0	64.0	67.0	71.0	77.0	86.0	93.0	100
127	0	8.0	15.0	22.0	28.0	33.0	38.0	42.0	46.0	50.0	52.0	53.0	53.0	53.0	53.0	54.0	55.0	57.0	59.0	63.0	68.0	75.0	83.0	92.0	100
128	0	8.0	15.0	22.0	29.0	34.0	40.0	45.0	48.0	51.0	54.0	57.0	59.0	62.0	63.0	64.0	65.0	66.0	67.0	69.0	72.0	76.0	83.0	91.0	100
129	0	9.0	16.0	22.0	27.0	32.0	37.0	41.0	45.0	48.0	51.0	53.0	55.0	56.0	57.0	57.0	58.0	59.0	61.0	64.0	68.0	73.0	79.0	89.0	100
130	0	10.0	20.0	28.0	35.0	41.0	46.0	49.0	51.0	53.0	55.0	56.0	56.0	57.0	58.0	59.0	60.0	61.0	62.0	65.0	69.0	74.0	81.0	90.0	100
131	0	8.0	15.0	22.0	28.0	33.0	38.0	41.0	44.0	47.0	49.0	51.0	53.0	55.0	56.0	58.0	59.0	60.0	63.0	65.0	69.0	75.0	84.0	92.0	100
132	0	10.0	18.0	25.0	29.0	33.0	36.0	39.0	41.0	42.0	44.0	45.0	46.0	47.0	48.0	49.0	51.0	53.0	56.0	59.0	64.0	70.0	80.0	90.0	100
133	0	8.0	16.0	24.0	32.0	40.0	46.0	51.0	54.0	56.0	57.0	58.0	58.0	59.0	59.0	60.0	60.0	61.0	62.0	64.0	68.0	74.0	83.0	91.0	100
134	0	12.0	22.0	31.0	39.0	45.0	49.0	52.0	54.0	55.0	56.0	56.0	56.0	56.0	57.0	57.0	57.0	57.0	58.0	59.0	62.0	68.0	77.0	88.0	100
135	0	7.0	15.0	22.0	30.0	37.0	43.0	49.0	53.0	55.0	57.0	58.0	59.0	60.0	61.0	62.0	63.0	65.0	67.0	70.0	74.0	79.0	85.0	92.0	100
136	0	11.0	21.0	29.0	37.0	44.0	50.0	55.0	57.0	59.0	60.0	60.0	60.0	60.0	61.0	61.0	61.0	62.0	63.0	64.0	67.0	71.0	78.0	89.0	100
137	0	10.0	18.0	25.0	30.0	39.0	46.0	51.0	54.0	57.0	58.0	59.0	59.0	60.0	60.0	60.0	61.0	62.0	63.0	64.0	67.0	72.0	80.0	90.0	100
138	0	11.0	22.0	31.0	39.0	46.0	52.0	56.0	58.0	59.0	60.0	61.0	61.0	61.0	61.0	62.0	62.0	62.0	63.0	64.0	66.0	71.0	78.0	89.0	100
139	0	8.0	14.0	20.0	25.0	32.0	37.0	42.0	47.0	50.0	53.0	55.0	56.0	58.0	59.0	61.0	63.0	64.0	66.0	68.0	71.0	76.0	85.0	93.0	100
140	0	13.0	18.0	43.0	56.0	65.0	69.0	69.4	69.7	70.1	70.4	70.8	71.1	71.5	71.9	72.2	72.6	73.0	73.3	73.6	74.0	76.0	81.0	89.0	100

Figure 4 - Isoerodent Map of California
Closeup View of Project



Google Earth Pro

miles 9
km 10

HDR | ONE COMPANY *Many Solutions*™

Project: Redlands Passenger Rail	Computed: B.F.	Date: 4/26/12	
Subject: R-Factor	Checked:	Date:	
Task:	Page:	of:	
Job #:	No:		

Assume Const. Schedule

Begin const: Jan 1, 2015

End const: Dec 31, 2017

EI => 2015, from Jan 1 to Dec 31

100 - 0 = 100 %

2016, => 100 %

2017 => 100 %

EI = 3(100) = 300 %

R value = Isocrodent value x EI

= 40 x 3.00

= 120

Flores, Bill

From: Kim, Tae
Sent: Monday, May 07, 2012 9:57 AM
To: Flores, Bill
Cc: Goldman, Gary; Molinaro, Joe; Boraks, Michael
Subject: RE: Info required for PWQMP (RPRP)

Bill,
As requested, here are the preliminary values of Soil Erodibility and permeability of the alignment.
Please let me know if you have any question.

Preliminary Permeability and Soil Erodibility – Near Surface Soils

Station No	Generalized Soil Type (near surface soils)	Permeability (10^{-4} cm/sec)	Soil Erodibility Factor
100+00 to 202+00	Silty Sand	20	0.17
202+00 to 332+00	Silt/Sandy Silt	1-5 (Average 3)	0.42
332+00 to 579+00	Silty Sand	20	0.17

TAE KUK KIM, MS, PE, GE
HDR Engineering, Inc.
Senior Geotechnical Engineer

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o: 714.730.2435| c: 714.296.2891
tae.kim@hdrinc.com | hdrinc.com

Follow Us - Facebook | Twitter | YouTube

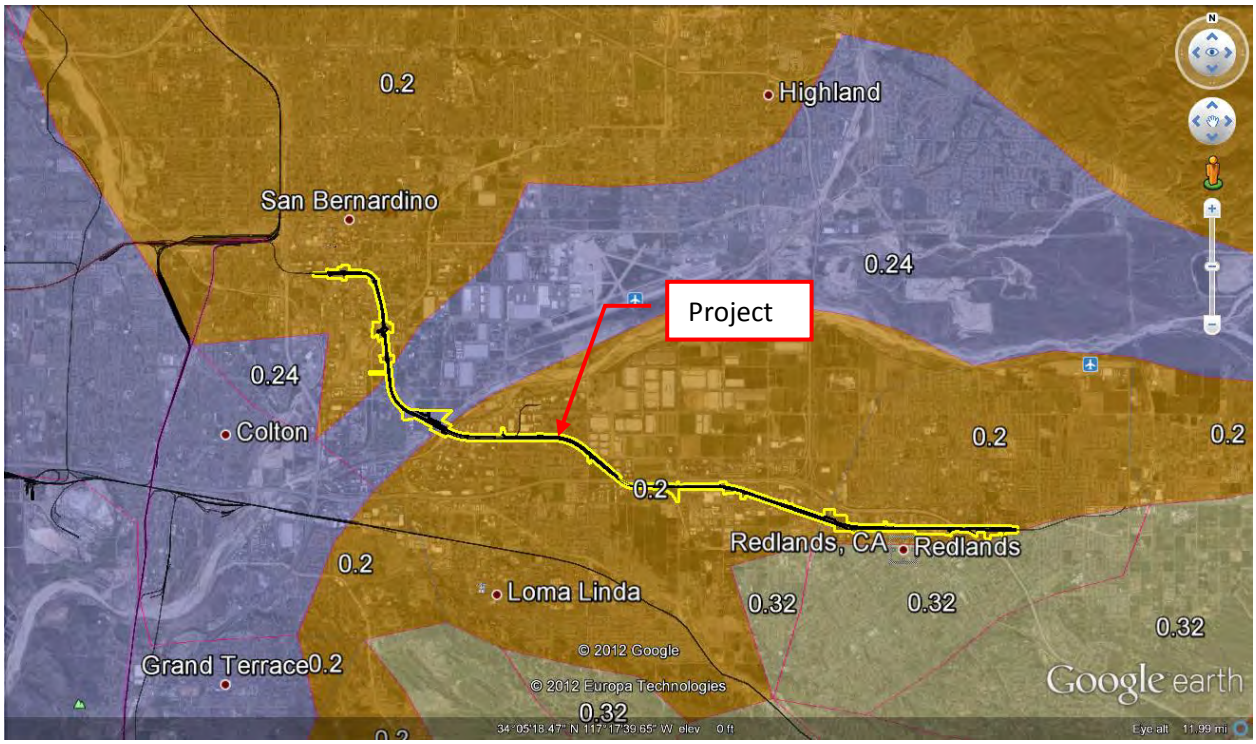
From: Flores, Bill
Sent: Friday, April 27, 2012 10:52 AM
To: Kim, Tae
Cc: Goldman, Gary
Subject: RE: Info required for PWQMP (RPRP)

When you get a chance please provide K value on State provide triangle nomograph. I got a prelim number from Google Earth. This minimal effort should be included already in your scope. Please call with questions.

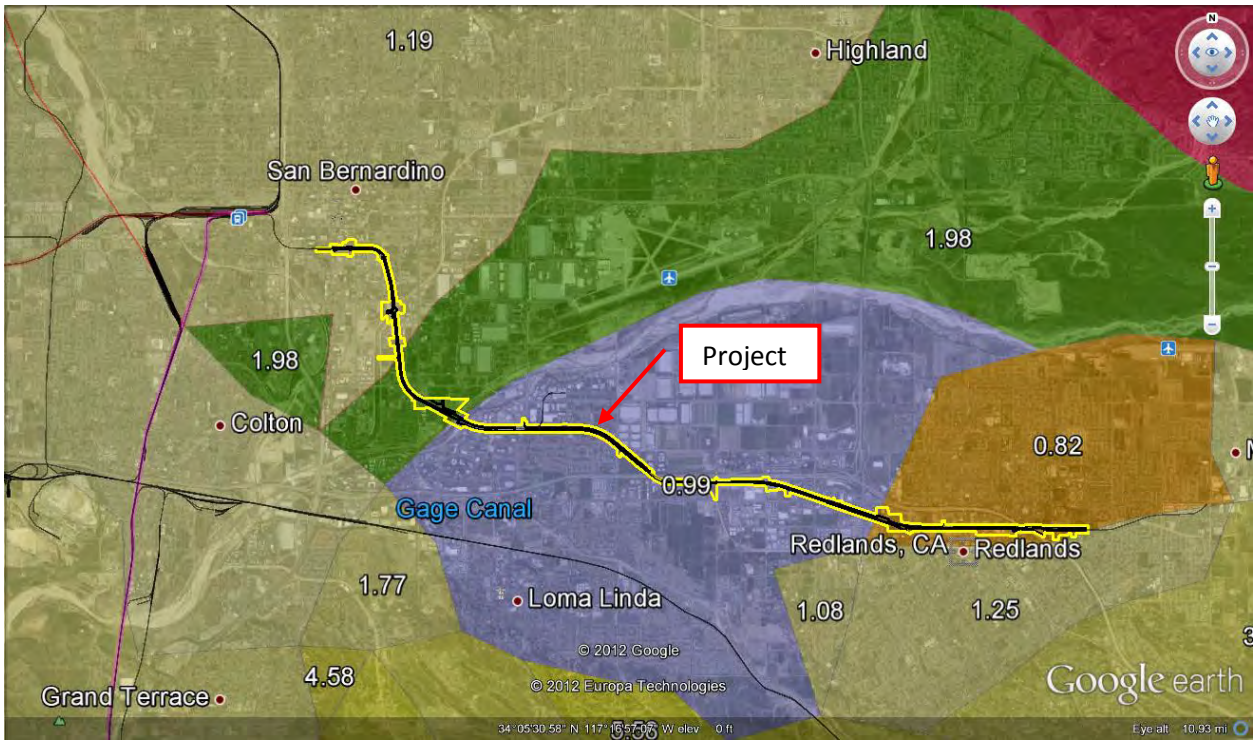
Bill Flores

From: Kim, Tae
Sent: Wednesday, April 25, 2012 1:10 PM
To: Flores, Bill

K Factor from Google Earth



LS Factor from Google Earth



Sheet Flow Length (ft)	Average Watershed Slope (%)																		
	0.2	0.5	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	12.0	14.0	16.0	20.0	25.0	30.0	40.0	50.0	60.0
<3	0.05	0.07	0.09	0.13	0.17	0.20	0.23	0.26	0.32	0.35	0.36	0.38	0.39	0.41	0.45	0.48	0.53	0.58	0.63
6	0.05	0.07	0.09	0.13	0.17	0.20	0.23	0.26	0.32	0.37	0.41	0.45	0.49	0.56	0.64	0.72	0.85	0.97	1.07
9	0.05	0.07	0.09	0.13	0.17	0.20	0.23	0.26	0.32	0.38	0.45	0.51	0.56	0.67	0.80	0.91	1.13	1.31	1.47
12	0.05	0.07	0.09	0.13	0.17	0.20	0.23	0.26	0.32	0.39	0.47	0.55	0.62	0.76	0.93	1.08	1.37	1.62	1.84
15	0.05	0.07	0.09	0.13	0.17	0.20	0.23	0.26	0.32	0.40	0.49	0.58	0.67	0.84	1.04	1.24	1.59	1.91	2.19
25	0.05	0.07	0.10	0.16	0.21	0.26	0.31	0.36	0.45	0.57	0.71	0.85	0.98	1.24	1.56	1.86	2.41	2.91	3.36
50	0.05	0.08	0.13	0.21	0.30	0.38	0.46	0.54	0.70	0.91	1.15	1.40	1.64	2.10	2.67	3.22	4.24	5.16	5.97
75	0.05	0.08	0.14	0.25	0.36	0.47	0.58	0.69	0.91	1.20	1.54	1.87	2.21	2.86	3.67	4.44	5.89	7.20	8.37
100	0.05	0.09	0.15	0.28	0.41	0.55	0.68	0.82	1.10	1.46	1.88	2.31	2.73	3.57	4.59	5.58	7.44	9.13	10.63
150	0.05	0.09	0.17	0.33	0.50	0.68	0.86	1.05	1.43	1.92	2.51	3.09	3.68	4.85	6.30	7.70	10.35	12.75	14.89
200	0.06	0.10	0.18	0.37	0.57	0.79	1.02	1.25	1.72	2.34	3.07	3.81	4.56	6.04	7.88	9.67	13.07	16.16	18.92
250	0.06	0.10	0.19	0.40	0.64	0.89	1.16	1.43	1.99	2.72	3.60	4.48	5.37	7.16	9.38	11.55	15.67	19.42	22.78
300	0.06	0.10	0.20	0.43	0.69	0.98	1.28	1.60	2.24	3.09	4.09	5.11	6.15	8.23	10.81	13.35	18.17	22.57	26.51
400	0.06	0.11	0.22	0.48	0.80	1.14	1.51	1.90	2.70	3.75	5.01	6.30	7.60	10.24	13.53	16.77	22.95	28.60	33.67
600	0.06	0.12	0.24	0.56	0.96	1.42	1.91	2.43	3.52	4.95	6.67	8.45	10.26	13.94	18.57	23.14	31.89	39.95	47.18
800	0.06	0.12	0.26	0.63	1.10	1.65	2.25	2.89	4.24	6.03	8.17	10.40	12.69	17.35	23.24	29.07	40.29	50.63	59.93
1000	0.06	0.13	0.27	0.69	1.23	1.86	2.55	3.30	4.91	7.02	9.57	12.23	14.96	20.57	27.66	34.71	48.29	60.84	72.15

LS Factors for Construction Sites. *Table from Renard et. al., 1997.*

As applicable, a more refined LS factor should be determined using cross sections at specific spacings. Refer to Caltrans LS Factor method.

Receiving Water (RW) Risk Factor Worksheet	Entry	Score
A. Watershed Characteristics	**yes/no**	
A.1. Does the disturbed area discharge (either directly or indirectly) to a **303(d)-listed waterbody impaired by sediment** (For help with impaired waterbodies please visit the link below) or has a **USEPA approved TMDL implementation plan for sediment**?:	**no**	**Low**
http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml		
OR		
A.2. Does the disturbed area discharge to a waterbody with designated beneficial uses of SPAWN & COLD & MIGRATORY? (For help please review the appropriate Regional Board Basin Plan)		
http://www.waterboards.ca.gov/waterboards_map.shtml		

2006 CWA SECTION 303(d) LIST OF WATER QUALITY LIMITED SEGMENTS REQUIRING TMDLS

SANTA ANA REGIONAL WATER QUALITY CONTROL BOARD

USEPA APPROVAL DATE: JUNE 28, 2007

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
8	R	San Diego Creek Reach 2	80111000	Metals	Urban Runoff/Storm Sewers	6.3 Miles	2007
8	R	Santa Ana River, Reach 4	80127000	Pathogens	Nonpoint Source	14 Miles	2019
8	R	Santiago Creek, Reach 4	80112000	Salinity/TDS/Chlorides	Source Unknown	9.8 Miles	2019
8	C	Seal Beach	80111000	Enterococcus *Impaired 50 yards around drain at 1st Street.*	Source Unknown	0.53 Miles	2019
				PCBs (Polychlorinated biphenyls)	Source Unknown	0.53 Miles	2019
8	R	Silverado Creek	80112000	Pathogens	Unknown Nonpoint Source	11 Miles	2019
				Salinity/TDS/Chlorides	Unknown Nonpoint Source	11 Miles	2019
8	R	Summit Creek	80171000	Nutrients	Construction/Land Development	1.5 Miles	2008

2006 CWA SECTION 303(d) LIST OF WATER QUALITY LIMITED SEGMENTS REQUIRING TMDLS

SANTA ANA REGIONAL WATER QUALITY CONTROL BOARD

USEPA APPROVAL DATE: JUNE 28, 2007

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION

ABBREVIATIONS

REGIONAL WATER QUALITY CONTROL BOARDS

1	North Coast
2	San Francisco Bay
3	Central Coast
4	Los Angeles
5	Central Valley
6	Lahontan
7	Colorado River Basin
8	Santa Ana
9	San Diego

WATER BODY TYPE

B =	Bays and Harbors
C =	Coastal Shorelines/Beaches
E =	Estuaries
L =	Lakes/Reserviors
R =	Rivers and Streams
S =	Saline Lakes
T =	Wetlands, Tidal
W=	Wetlands, Freshwater

CALWATER WATERSHED

"Calwater Watershed" is the State Water Resources Control Board hydrological subunit area or an even smaller area delineation.

GROUP A PESTICIDES OR CHEM A

aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan, and toxaphene

2010 California 303(d) List of Water Quality Limited Segments*

Water quality limited segments requiring a TMDL(5A), being addressed by TMDL(5B), and/or being addressed by an action other than TMDL(5C).

REGION	REGION NAME	WATER BODY NAME	WBID	WATER BODY TYPE	WATER BODY TYPE CODE	INTEGRATED REPORT CATEGORY	USGS CATALOGING UNIT	CALWATER WATERSHED	ESTIMATED SIZE AFFECTED	UNIT	POLLUTANT	POLLUTANT CATEGORY	FINAL LISTING DECISION	TMDL REQUIREMENT STATUS**	EXPECTED TMDL COMPLETION DATE***	EXPECTED ATTAINMENT DATE***	USEPA TMDL APPROVED DATE***	COMMENTS INCLUDED ON 303(d) LIST	POTENTIAL SOURCES	SOURCE CATEGORY
8	Regional Board 8 - Santa Ana Region	Santa Ana River, Reach 4	CAR8012700019990211142130	River & Stream	R	5	18070203	80127000	14	Miles	Pathogens	Pathogens	List on 303(d) list (TMDL required list)	5A	2019				Nonpoint Source	Unspecified Nonpoint Source

Meaning that the tables include listings still requiring the development of a TMDL, those that have a completed TMDL approved by USEPA, and those that are being addressed by actions other than a TMDL.

* USGS HUC = US Geological Survey Hydrologic Unit Code. Calwater = State Water Resources Control Board hydrological subunit area or even smaller planning watershed.

** TMDL requirement status definitions for listed pollutants are: A= TMDL still required, B= being addressed by USEPA approved TMDL, C= being addressed by action other than a TMDL

*** Dates relate to the TMDL requirement status, so there will only be one applicable date for each listing.

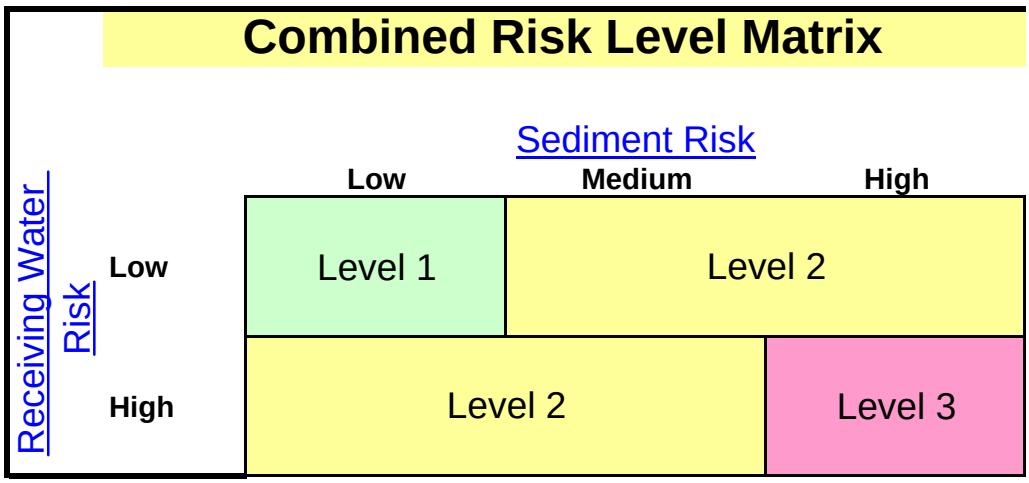
Table 3-1 BENEFICIAL USES - Continued

INLAND SURFACE STREAMS	BENEFICIAL USE																		Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	EST	Primary	Secondary
UPPER SANTA ANA RIVER BASIN																				
Santa Ana River																				
Reach 3 – Prado Dam to Mission Blvd. in Riverside	+	X			X			X	X		X				X	X			801.21	801.21, 801.25
Reach 4 – Mission Blvd. in Riverside to San Jacinto Fault in San Bernardino	+				X			X[3]	X		X				X				801.27	801.44
Reach 5 – San Jacinto Fault in Bernardino to Seven Oaks Dam[t]	X*	X			X			X[3]	X		X				X	X			801.52	801.57
Reach 6 – Seven Oaks Dam to Headwaters (see also Individual Tributary Streams)	X	X			X		X	X	X				X		X		X		801.72	
San Bernardino Mountain Streams																				
Mill Creek Drainage:																				
Reach 1 – Confluence with Santa Ana River to Bridge Crossing Route 38 at Upper Powerhouse	I	I			I			I	I				I		I	I			801.58	
Reach 2 – Bridge Crossing Route 38 at Upper Powerhouse Headwaters	X	X			X		X	X	X				X		X				801.58	

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
\+ Excepted from MUN (see text)

* **MUN** applies upstream of Orange Avenue (Redlands); downstream, water is excepted from **MUN**
[t] Reach 5 uses are intermittent upstream of Waterman Avenue
[3] Access prohibited in some portions by San Bernardino County Flood Control

Combined Risk Level Matrix



Project Sediment Risk:	**Medium**
Project RW Risk:	**Low**
Project Combined Risk:	**Level 2**